

THE COMPLETE OBSERVATIONS

CONTAINING THE

Various Methods of finding the LATITUDE

When the SUN is in the MERIDIAN,

AND ALSO

By TWO ALTITUDES,

Either Equal or Unequal, when out of the MERIDIAN,

TOGETHER WITH

A NEW METHOD of finding the LATITUDE

By ONE ALTITUDE ONLY,

AT ANY HOUR WHEN THE SUN CAN BE SEEN,

AND OF

CORRECTING the WATCH,

NEVER BEFORE PUBLISHED.

AND ALSO

A NEW METHOD of finding the LATITUDE

Without knowing the SUN's DECLINATION,

In any HIGH LATITUDE either NORTH or SOUTH,

And if the DAY of the MONTH be Lost, how to Find it.

With a COMPLETE SET of TABLES.

TO THE WHOLE IS ADDED

The METHOD of DETERMINING the

L O N G I T U D E

By LUNAR OBSERVATIONS.

TOGETHER WITH

A New, Concise, Easy, and Infallible Method of

DETERMINING the LONGITUDE

By an Observation either of the MOON or Fixt STAR,

BY ONE PERSON ONLY,

And an HADLEY's QUADRANT well adjusted.

By THOMAS HARRISON and SON.

Y O R K: *K*

PRINTED IN THE YEAR 1788.

THE
COMPLETE OBSERVATOR.

Containing the
Various Methods of finding the LATITUDE
When the SUN is in the MERIDIAN.

By W. O. WATSON.
A NEW METHOD OF FINDING THE LATITUDE
By OBSERVING THE ALTITUDE OF THE SUN
AT ANY TIME OF THE DAY.

By OBSERVING THE ALTITUDE OF THE SUN
AT ANY TIME OF THE DAY.



And if the DAY OF THE MONTH
BE KNOWN, THE TIME OF THE DAY
MAY BE FOUND.

By OBSERVING THE ALTITUDE OF THE SUN
AT ANY TIME OF THE DAY.

By OBSERVING THE ALTITUDE OF THE SUN
AT ANY TIME OF THE DAY.

By OBSERVING THE ALTITUDE OF THE SUN
AT ANY TIME OF THE DAY.

By OBSERVING THE ALTITUDE OF THE SUN
AT ANY TIME OF THE DAY.

P R E F A C E.

WHEN we consider the utility of observations to mariners in general, and to those that trade into foreign parts in particular, we need not be surpris'd that so many efforts have been made to bring this useful branch of learning to the utmost degree of perfection: and though a vast extent of tracts on this subject have appeared, yet none have been under our inspection that have handled every circumstance easy to be understood by the generality of readers. In this small treatise we have endeavour'd to render every example as easy as possible, and we hope it will enable those who are acquainted with the first principles, to attain (without the assistance of a Master) a competent knowledge with ease and precision.

We humbly hope it will merit the approbation of those Gentlemen who have interest'd themselves in behalf of our endeavours, to whom we return our most sincere thanks, and are, with the utmost esteem and respect,

Their's and the Public's most obliged,

And obedient, humble servants,

THOMAS and JAMES HARRISON.

P R E F A C E

WHEN we consider the utility of observations to mankind in general, and to those that trade into foreign parts in particular, we need not be surprised that so many efforts have been made to bring this useful branch of learning to the most degree of perfection: and though a vast extent of trade on this subject have appeared, yet none have been under our inspection that have furnished every circumstance necessary to the attainment of the generality of readers. In this small treatise we have endeavoured to render every example as easy as possible, and we hope it will be useful to those who are acquainted with the principles of navigation, (without the assistance of a Master) a competent knowledge with calculation and precision.

We humbly hope it will merit the approbation of those Gentlemen who have interested themselves on behalf of our country, to whom we return our most sincere thanks, and are



T H E

COMPLETE OBSERVATOR.

C H A P. I.

*To find the Latitude of a Place, from the greatest Meridian
Altitude of any Cælestial Body.*

R U L E.

IF the zenith distance and declination be of one name, their difference is the latitude; if not, their sum is the latitude of the same name with the declination, except when the declination is subtracted from the zenith distance: but if the zenith distance and declination of the object be of different names, it is evident that the object must be between the zenith and equator. The distance between the zenith and the equator, or latitude, must therefore be equal to the zenith distance of the object added to its declination; and because the zenith lies on the same side of the equator as the object, the latitude will always be of the same name with the declination.

There are but four cases, or varieties, in working of observations by the Sun's meridian altitude, in whatsoever part of the world you are in, or whether the Sun's declination be North or South.

The first is, when the Sun is between the horizon and the equator; and then the RULE is, subtract the declination from the zenith; distance the remainder is the latitude of the place.

B

EXAMPLE.

THE COMPLETE OBSERVATOR.

E X A M P L E.

Suppose the Sun's zenith distance 76° ; and the Sun's declination 16° South, what is the latitude?

N. B. The zenith distance is found by subtracting the corrected altitude from 90° , the remainder is the zenith distance.

				90°	
<i>Meridian altitude corrected</i>	-			<u>14</u>	
<i>Zenith distance</i>	-		-	76	} <i>Sub.</i>
<i>Sun's declination</i>	-		-	<u>16</u>	
<i>Latitude</i>	-	-	-	60	<i>required</i>

The second is, when the Sun is between the equator and zenith; then the RULE is, add the Sun's declination to his zenith distance; the sum is the latitude of the place.

E X A M P L E.

Being at sea 27th of May, 1786, the Sun's meridian altitude was found $57^{\circ} 35'$, and it was south of me; what was the latitude of the place?

				90°	
<i>Meridian altitude corrected</i>	-			<u>57 35</u>	
<i>Zenith distance</i>	-	-	-	32 25	
<i>Sun's declination</i>	-	-	-	<u>21 23</u>	
				53 48	<i>North</i>

The third variety is, when the Sun is between the zenith and elevated pole; then the RULE is, subtract the zenith distance from the Sun's declination; the remainder is the latitude required.

E X A M P L E.

Being at sea 14th of January, 1784, the Sun's meridian altitude was found $72^{\circ} 17'$ S. what was the latitude of the place?

				$90^{\circ} 00'$	
<i>Meridian altitude</i>	-		-	<u>72 17</u>	
<i>Zenith distance</i>	-	-	-	17 43	<i>South</i>
<i>Declination</i>	-	-	-	<u>21 17</u>	<i>South</i>
<i>Latitude</i>	-	-	-	3 34	<i>South</i>

The

The fourth variety is, when the Sun or star is between the elevated pole and the horizon; and then the RULE is, subtract the complement of the Sun's declination from the zenith distance; the remainder is the complement of the latitude.

E X A M P L E.

Being at sea July 12th, 1787, the Sun's declination $22^{\circ} 00'$, and his corrected altitude was found to be $= 05^{\circ}$; require the latitude?

				$9^{\circ} 0'$	
Sun's altitude	-	-	-	05	
Zenith	-	-	-	85	distance
Complement	-	-	-	68	sun declin.
Complement	-	-	-	17	of latitude
				90	
				<hr/>	
				73	Latitude

But because it seldom happens that any sail so far North or South, as that they can conveniently take a backward observation by the Sun, under the elevated pole; in such case it may be done by forward observation, and work with the Sun's altitude or height above the horizon; and then the RULE is, add the Sun's altitude to the complement of the Sun's declination; the sum is the latitude; thus

Sun's altitude	-	-	05°
Complement Sun's declination	-	-	68
			<hr/>
Latitude required	-	-	73.

The same operations will hold good in taking an observation by a star or planet.

In using an Hadley's Quadrant the Sun's altitude must be corrected for dip, refraction, and Sun's semidiameter.

E X A M P L E.

By a fore observation the altitude of the Sun's lower edge was taken and found to be $40^{\circ} 20'$ South of the observer, when his declination was $9^{\circ} 56'$ North; the eye being 30 feet above the horizon; require his true meridian altitude and latitude observed in?

Obf.

THE COMPLETE OBSERVATOR.

<i>Obs. alt. Sun's lower edge</i>	-	-	40° 2' 0" S
<i>Semidiameter to be added</i>	-	-	0 16
<hr/>			
<i>App. alt. Sun's centre</i>	-	-	40 36
<i>Dip of the horizon, to be subtr.</i>	-	-	0 05
<hr/>			
<i>App. alt. cor. by the dip</i>	-	-	40 31
<i>Refraction to be subtracted</i>	-	-	0 01
<hr/>			
<i>True altitude Sun's centre</i>	-	-	40 30
<i>True zenith distance</i>	-	-	49 30
<i>Declination add.</i>	-	-	9 56 N
<hr/>			
<i>Latitude</i>	-	-	59 26

By a back observation with Hadley's Quadrant, suppose the apparent altitude of the Sun's upper edge was taken 25° 12' South, when his declination was 21° 14' South, the eye 40 feet above the horizon; in what latitude was the observation made?

<i>By observation alt.</i>	-	-	25° 12'
<i>Semidiameter to be subtr.</i>	-	-	16
<hr/>			
<i>App. Sun's cen. of the Sun</i>	-	-	24 56
<i>Dip of horizon to be added</i>	-	-	2 06
<hr/>			
<i>App. altitude cor. by dip</i>	-	-	25 02
<i>Refraction to be subtracted</i>	-	-	0 02
<hr/>			
<i>True altitude of Sun's centre</i>	-	-	25 00
<i>True zenith distance</i>	-	-	65 00 S
<i>Declination</i>	-	-	21 14 S
<hr/>			
<i>Latitude, North</i>	-	-	43 46

To find the Latitude by the Meridian Altitude of the Moon.

FIND the time of the Moon passing over the meridian of Greenwich in the ephemeris, to which apply the longitude of the ship or place, turned into time by Addition or Subtraction, according as the place is E. or W. which call *the reduced time*.

To this time find the Moon's semidiameter and horizontal parallax in the ephemeris for the month.

Correct

Correct the observed altitude for her semidiameter, dip, &c. to which add the correction for her observed altitude and horizontal parallax, and you will have her true altitude—hence the latitude as before.

To find the Latitude by the Meridian Altitude of any of the Planets.

IN the Nautical Almanack, find the time of the planet passing the meridian of Greenwich; reduce this time to the meridian of the ship; then having the altitude and declination, the latitude is found as by a fixed star, or the Sun.

C H A P. II.

The Method of finding the Latitude from the Observation of two Altitudes of the Sun, and the Time between each Altitude.

Cautions which relate to the proper times for making observations.

THE two observations must always be taken between nine in the morning and three in the afternoon, if possible; but, the nearer they are to noon, the truer your latitude, provided there be a sufficient interval between them. The following directions will be of use to shew what interval is proper.

If both altitudes are taken in the forenoon, the interval between them must not be much less than half the distance of the first altitude from noon.

If both altitudes are taken in the afternoon, the interval of time between them must not be much less than the first altitude from noon.

If one altitude was taken in the forenoon, and the other in the afternoon, the interval of time between them must not exceed four hours and a half.

These cautions will give the Mariner sufficient reason to see there are many exceptions to the finding the latitude by two altitudes; and the same is attended with much trouble; I therefore think the method to find the latitude by one altitude only, (at any hour of the day) preferable; but that the

Mariner may be properly instructed how to find the same by two altitudes, the following RULES will sufficiently qualify him to perform the same.

R U L E S.

I. Find the arithmetical complement of the logarithm, co. sine of latitude by account, add the arithmetical complement of the logarithm co-sine of the Sun's declination : call their sum *the log. ratio*.

II. From the natural sine of the greatest altitude, subtract the natural sine of the least altitude ; find the logarithm of their difference, and write it under log. ratio.

III. With half the elapsed time under Table 4, and from the column of half the elapsed time, take out the logarithm answering thereunto, which is also to be set down under log. ratio.

It is sufficiently correct (for common use) to take the time to half a minute, but if greater accuracy be required, the difference between the two nearest logarithms must be applied.

IV. Add these three logarithms together, and with their sum enter the table in the column of the middle line ; where having found the logarithm nearest thereto, take out the time corresponding to it, and put it down under half the elapsed time ; subtract the lesser from the greater, their difference will be the time from noon, when the greatest altitude was taken.

V. With this time enter the table ; and from the column of log. rising, take out logarithm corresponding thereto : from this logarithm of a natural number, which, being found in the common table of logarithms, and added to the natural sine of the greatest altitude, will give the natural sine of the meridian altitude of the Sun.

From the meridian altitude of the Sun, the latitude is easily obtained by the rules for finding the same at the beginning of this book.

N. B. If the latitude found by this process should differ widely from the latitude by account, it will be proper to repeat the operation, using the latitude last found instead of the latitude by account, till the result gives a latitude nearly agreeing with the latitude used in the computation.

EXAMPLES.

E X A M P L E S.

Being at sea in the latitude of $47^{\circ} 19'$, by account, when the Sun's declination was $12^{\circ} 16' N.$ at 10 h. 24' A. M. per watch, the Sun's altitude was found $49^{\circ} 09'$, and at 1 h. 14' P. M. per watch, his altitude was found $51^{\circ} 59'$: require the true latitude?

Times			Altit.			
H.	M.	S.	D.	M.	Nat. sines	
10.	24.	00	\times	$49^{\circ} 00'$	75642	S. dec. $47^{\circ} 19' - 0.16880$
1.	14.	00		51. 59	78783	$12. 16 - 0.01003$
					log. rat.	0.17883
Elap. time	2.	50. 00			3141 its logar.	3.49707
$\frac{1}{2}$ elap. time	1.	25. 00			its log. in col. of half elap. time is	0.44077
	0.	15. 00			in col. of M. T. corresponding to	4.11667
Time at noon	1.	10. 00			its log. from col. of L. rising is	3.66542
Ditto per watch	1.	14			- log. ratio	0.17883
Watch fast	0.	4. 00			3066 nat. num. of this log.	3.48659
					78783	
Sun mer. alt.	$54^{\circ} 56'$				81849 nat. sine of Sun's mer. alt.	
Sun's	35. 4				zenith distance	
Sun's dec.	12. 16				North	
Latitude	47. 20				in North	

Here the latitude, found by computation, may be relied on, as it differs only one mile from the latitude used in the operation. It is hardly necessary to observe, that by the Sun's altitude is always meant its correct altitude.

E X A M P L E II.

Being at sea, in latitude by account $50^{\circ} 40'$ North, when the Sun's declination was $20^{\circ} 00'$ South, at 10 h. 17' A. M. per watch, the Sun's altitude was taken $17^{\circ} 13'$, and at 11 h. 17' A. M. per watch, it was taken $19^{\circ} 41'$: require the true latitude?

Times

<i>Times.</i>			<i>Alt.</i>	<i>D. M.</i>	
H.	M.	S.	D. M.	<i>Nat. fines</i>	<i>Lat.</i>
10.	17.	00	17.	13 = 29599	50. 40—0.19803
					<i>S. dec.</i> 20. 00—0.02701
11.	17.	00	19.	41 = 33682	<i>Log. rat.</i> 0.22504
<i>Elap. time</i>	1.	00. 00		4083	3.61098
$\frac{1}{2}$ <i>elap. time</i>	0.	30. 00			0.88430
	1.	1. 00	<i>in col. of M. T. corresponding</i>		
					4.72032
<i>Time from noon</i>	0.	31. 00			2.95529
<i>Ditto per watch</i>	0.	43. 00			0.22504
<i>Watch slow</i>	0.	12. 00		538	2.73025
				33682	

Natural fine Sun's mer. alt. $34220 = 20^{\circ}. 01' = \text{Sun's alt.}$
 69. 59 *Sun's zen. dist.*
 20. 00 *Sun's dec.*
 49. 59 *Latitude.*

As the latitude, by this computation, differs 41' miles from that by account, it is proper to repeat the operation, using the last-found latitude, instead of that by account.

			<i>D. M.</i>	
			49. 59	0.19178
			20. 00	0.02701
				0.21879
<i>Half elap.</i>	H. M. S.	<i>time</i>	<i>Log. ratio</i>	0.88430
	0.	30. 00		
	1.	00. 00		4.71407
	0.	30. 00		2.93223
	0.	43. 00		0.21879
<i>Watch slow</i>	0.	13. 00		2.71344
			517	
			33682	
			34199 =	20. 00
			70. 00 =	<i>Sun's zen. dist.</i>
			20. 00 =	<i>Sun's declination</i>
			50. 00	<i>Latitude</i>

The latitude last found, differing only one mile from that used in the operation, may be relied on as the true latitude.

EXAMPLE

E X A M P L E III.

Being at sea in latitude, by account, $60^{\circ} 0'$; when the sun had no declination; at 1 h. 0' P. M. per watch, his altitude was $28^{\circ} 53'$, and at 3 h. 0' P. M. per watch, it was $20^{\circ} 42'$: require the true latitude?

<i>Times</i>		D. M.		D. M.
H. M. S.			Lat.	
1. 00. 00		25. 53 = 48303	Sun's dec.	00. 00
				0.30103
3. 00. 00		20. 42 = 35348		0.00000
			Log. rat.	0.30103
2. 00. 00		12955		4.11244
$\frac{1}{2}$ elap. time 1. 00. 00				0.58700
2. 00. 00				5.00047
Time from noon 1. 00. 00				3.53243
			Log. rat.	0.30103
				3.23140
		1703		
		48303	D. M.	
		50006 = 30. 00	Sun's mer. alt.	
		60. 00	Latitude	

Here the latitude by computation comes out the same with the latitude by account, which shews that the latitude by account was right. From the foregoing examples it is plain that the operation is the same, whether the Sun has North or South declination, and will be the same whether the ship is in North or South latitude. It is also clear, that when the Sun has no declination, the arithmetical complement of the log. co-sine of the latitude is the log. ratio.

Hereto it has been supposed that both the altitudes were taken at the same place or station; but as that can seldom happen at sea, the necessary corrections for any alterations in your station may be readily made as follows:

Let the bearing of the Sun, at the instant of the first observation, be taken by the compass, which call *the Sun's bearing*; and when the second observation is taken, find how far the ship has gone, in the time between the observations, towards or from that point of the horizon in which the ship hath gone, in the time. This quantity added to the aforesaid altitude, if the ship hath moved towards the aforesaid point, or right subtracted from the first altitude,

D

altitude, if the ship hath gone farther from the said point, will reduce the first altitude to what it would have been found, if observed at the same station where the second altitude was taken.

Thus suppose that when the Sun bore S. E. $\frac{1}{2}$ E. by the compass, his altitude was observed $18^{\circ} 27'$; and three hours after, it was observed $38^{\circ} 23'$; the ship in the mean-time having gone S. E. $\frac{1}{2}$ E. by the compass, at the rate of 6 knots per hour: require what the first altitude would have been found if it had been taken at the same place as the second was?

Here the ship's course was directly towards that point of the horizon the Sun bore on when the first altitude was taken; the whole distance run between the altitudes being 18 miles, must be added to the first altitude, which will make it what it would have been if it had been taken at the second station; so that the two altitudes for finding the latitude at the last station will be found $18^{\circ} 45'$ and $38^{\circ} 23'$.

But if the ship had sailed N. W. $\frac{1}{2}$ W. or directly from the point that the Sun bore on at the time of the first altitude, in such a case the 18 miles must have been subtracted from the first altitude.

When the ship's course makes an obtuse or an acute angle with the Sun's bearing, the distance gone towards, or from, that point that the Sun bore on, may be readily found by the help of the Tables of Difference of Latitude and Departure.

Thus suppose, that when the Sun bore S. E. b. S. by the compass, the altitude was taken $26^{\circ} 50'$; and after sailing 18 miles on a South course by the compass, his altitude was taken $37^{\circ} 10'$: require what the first altitude would have been if it had been taken at the second station?

Here the ship's course, making an angle of 3 points, or $33^{\circ} 45'$ with the Sun's bearing, find in the Table of Difference of Latitude and Departure what the difference of latitude will be when its course is 3 points, and distance 18 miles, and you will find 15 miles to be added to the first altitude, the ship having gone so much towards the point the Sun bore on; so that the two altitudes to be used at the second station for finding the latitude will be $27^{\circ} 05'$ and $37^{\circ} 10'$.

Had the ship's course been North, or 3 points from the point opposite to the Sun's bearing, in that case the 15 miles must have been subtracted from the first altitude.

When the ship's course is at right angles, or eight points from it, such cases need no correction.

EXAMPLE.

E X A M P L E.

Suppose a ship at 9 h. 55' 30" A. M. per watch, observes the altitude of the Sun to be $17^{\circ} 33'$ South, viz. bearing S. b. E. $\frac{1}{4}$ E; then sails 7 knots per hour, on an E. $\frac{1}{2}$ S. course, by the compass, and at o. h. 54' 10" P. M. per watch took the Sun's altitude $21^{\circ} 55'$: require the latitude of the ship, when the last altitude was taken, the declination of the Sun being $19^{\circ} 30'$ South, and the latitude, by account, being $47^{\circ} 34'$ North?

The ship's course, in this case, makes an angle with the bearing of the Sun of $64'$ points, and the distance run between the altitudes is 21 miles; therefore from the Tables of Difference and Departure, the difference of latitude answering the course and distance = 7 miles to be added to the first altitude, the ship having gone so much towards the point of the horizon the Sun then bore upon; so the two altitudes to be used for finding the latitude of the last station are $17^{\circ} 40'$ and $21^{\circ} 55'$.

1st alt. $17^{\circ} 33'$			
Cor. $\times 7$ Nat. fines		D. M.	0.17087
		Latit. 47. 34	
H. M. S.	17. 40 = 30348	S. dec. 19. 30	0.02565
9. 55. 30	21. 55 = 37326	Log. ratio	0.19652
0. 54. 10	6978		3.84373
2. 58. 40			
$\frac{1}{2}$ elap. time 1. 29. 30			0.41945
0. 33. 00			4.45970
Time from noon 0. 56. 00			3.47282
Ditto per watch 0. 54. 10			0.19652
Watch slow 9. 1. 50	1889		3.27630
Natural sine of the greatest altitude	37326	D. M.	
Natural sine of the Sun's merid. alt.	39215 =	23. 05 M. A.	
		66. 55 Sun's zen. dist.	
		19. 30 Sun's dec.	
		47. 25 Latitude	

C H A P. III.

To find the Apparent Time at Sea, and thereby regulate the Going of the Watch.

AMONG the many methods proposed for this purpose, that of equal altitudes seems the easiest to practise at sea. At the time when you think the watch stands in need of being regulated for an observation for finding the latitude at any hour of the day, by a single altitude, let the Sun's altitude be taken at any convenient time in the forenoon; set down the time and altitude; in the afternoon wait for the Sun having the same altitude exactly you had in the forenoon, and note down the times; then half the sum of those times is the apparent time shewn by the watch when the Sun was upon the meridian of the place.

Left the altitude taken in the forenoon cannot have a corresponding one in the afternoon, by the interposition of clouds, it is therefore proper to take several in the forenoon, in order to have a greater probability of securing a corresponding one in the afternoon; and if several observations of equal altitudes can be taken on both sides the meridian, it will be best to find the noon for each pair, and take the mean of all for the true one.

And if there is reason to believe the watch gains or loses considerably in a day, other sets of altitudes, on successive days, may be taken, whereby the daily variation of the watch may be known and allowed, by which means the artist will have nothing more to do in finding the latitude, by one altitude, than allowing what the watch gains or loses in a day, and the equation of time between the Sun and watch, and the latitude may be depended upon as true as any meridian altitude.

The altitudes should be taken in the same place, if possible; but if the ship cannot lie by the same, rules must be observed, what point the Sun bore upon when the first altitude was taken; and find the difference of latitude the ship has made since the first altitude was taken, by the Tables of Difference of Latitude and Departures, and add or subtract that difference as before directed.

EXAMPLE.

E X A M P L E.

March 1st, 1787, at 8 h. 40 m. in the forenoon, and at 3 h. 16 m. in the afternoon, the Sun had equal altitudes: require the going of the watch?

H.	M.	
8	40	} <i>add together</i>
12	00	
3	16	
<hr/>		
$\frac{1}{2}$ 23	56	
11	58	
12		
<hr/>		
0	02	<i>watch too fast</i>

Take notice, when the watch is fast, the half sum is less than 12 hours; when slow, then the half sum is more than twelve; when right, just twelve hours.

E X A M P L E II.

Feb. 28th, 1787, in latitude $54^{\circ} 30'$ North, at 8 h. 10 m. in the forenoon, and at 3 h. 58 m. I had equal altitudes of the Sun: how did the watch then go?

H.	M.	
8	10	} <i>add together</i>
12	00	
3	58	
<hr/>		
$\frac{1}{2}$ 24	08	<i>take half the sum</i>
12	04	<i>the apparent time</i>
12	00	
<hr/>		
04		<i>watch too slow</i>

E X A M P L E III.

April 24th, 1787, being at sea, and had at 10 h. 30 m. and 1 h. 30 m. equal altitudes: require the going of the watch?

H.	M.	
10	30	} <i>add together</i>
12	00	
1	30	
<hr/>		
$\frac{1}{2}$ 24	00	
12	00	<i>watch true</i>

D

CHAP.

C H A P. IV.

To find the Latitude of a Place, by one Altitude only, at any Time of the Day, when the Sun is above the Horizon, and can be seen.

R U L E S.

AS fine complement of the altitude is to the fine of the hour from noon, so is fine complement of Sun's declination to fine of the Sun's azimuth from the South, (if you are in the North altitude; but, if you are in South latitude, from the North) which being taken from 180° , gives you the azimuth from the North, if your latitude be North; but, if South, it gives the azimuth from the South. Then you have in the oblique spherical triangle two sides and two angles given, to find the other side, which may be solved as follows, viz. As the fine of $\frac{1}{2}$ the difference of the azimuth (of the same name with the latitude) and hour from noon is to the fine of their $\frac{1}{2}$ sum, so is the tangent of $\frac{1}{2}$ the difference of the complement of the altitude and complement of declination to the tangent of $\frac{1}{2}$ the complement of the latitude; which, being doubled, will give you the complement of the latitude; and that taken from 90° , will give you the latitude of the place: and if your watch can be depended upon, and properly corrected by a table, intituled, *A Table of Clock or Sun*, it will give you the latitude as true as any meridian altitude, and a little practise will make it as easy.

E X A M P L E I.

June 21st, 1785, at $38''$ past 10 in the morning, per watch, I took the Sun's altitude $53^\circ 45'$, what was the latitude of the place? By comparing the watch with equation of time, it is found $38''$ too fast, therefore it is by the Sun 10 o'clock in the morning: Then,

As S. C. of altitude	$53^\circ 45'$	9.77181
is to S. of the hour from noon	30. 00	{ 9.69807
so is S. C. of declination	66. 31	{ 9.96245
		19.66 42
to S. of Sun's azim. from South	50. 51	9.77181
		<u>9.88961</u>

Which, being subtracted from 180° , gives $129^\circ .09'$, the azimuth from the North.

	129° .09' .00''
Hour from noon	30 .00
Difference is	99 .09
Half their difference	49 .34 .30
Sum of the azimuth and hour from noon	$\frac{1}{2}$ 159° .09'
Half their sum	79° .34' .30''
Complement of altitude	36° 15'
Complement of declination	66 31
Difference	$\frac{1}{2}$ 30 16
Half their difference	15 8

Then

As S. of $\frac{1}{2}$ the difference of azim. and hour from noon	}	49° .34' .30''	9.88198
is to S. of their $\frac{1}{2}$ sum			
so is T. of $\frac{1}{2}$ the difference of co. of alt. and co. dep.	}	79 .34 .30	9.99277
		15 .08	9.43708
to T. of $\frac{1}{2}$ the com. of latitude		19 .14	9.54287
$\frac{1}{2}$ Complement		19 .14	
Doubled		2	
Gives complement of latitude		38 .28	
Subtracted from		90 .00	
Gives latitude in		51 .32	

E X A M P L E II.

Being on the North sea, January 9, 1785, I observed the Sun's altitude at 7' 38'' past 8 in the morning 1° 14', and his declination that day was 20 11' South: require the latitude?

Now, by comparing the watch with the equation of time, I find it 7' 38'' too fast; therefore by the Sun it is just 8 in the morning.

As

THE COMPLETE OBSERVATOR.

<i>As S. C. of altitude</i>	88° .46'	9.99990
<i>is to S. of hour from noon</i>	60 .00	9.93753
<i>so is S. C. of declination</i>	69 .49	9.97248

19.91001

9.99990

<i>to S. of Sun's azim. from the South</i>	54 .24	9.91011
--	--------	---------

Taken from 180° leaves 125° 36'

The azimuth from the North 125° .36'

Hour from noon 60 .00

Difference 65 .36

Half their difference 32 .48

Sum of the azim. and hour } 185 .36
from noon

Half their sum 92 .48

Complement of altitude 88 .46

Sun's distance from the North pole 110 .11

Difference 21 .25

Half their difference 10° .42' .30"

Then

As S. $\frac{1}{2}$ difference of azim. and hour } 32° .48' 9.73377
from noonis to S. $\frac{1}{2}$ their sum 92 .48 9.99948so is T. of $\frac{1}{2}$ difference of com. of } 10° .42' 30" 9.27669
alti. and com. of declin.

19.27617

9.73377

To T. com. of $\frac{1}{2}$ of latitude 19 .14 9.54240

doubled 38 .28

Complement of latitude 90 .00

subtracted from 90 .00

Gives the latitude in 51. 32 as before

EXAMPLE

E X A M P L E III.

March 20, 1782, I took the Sun's altitude at 7 in the morning, (when my watch was properly adjusted by the Table of Equation of Time) and found it $9^{\circ} 16'$, when I had made proper allowance for refraction and the height of my eye above the surface of the water; from which the latitude is required?

<i>As S. C. of altitude</i>	$9^{\circ} 16'$	9.99429
<i>is to S. of hour from noon</i>	75 .0	9.98494
<i>So S. C. of declination</i>	90 .0	10.00000
<i>to S. of the az. from the South</i>	78 .10	9.99065

78 $10'$ taken from 180° gives the azimuth from the North. Then,

<i>Azimuth from the North</i>	$101^{\circ} 50'$
<i>Hour from noon</i>	75 00
<i>Their difference</i>	26 50
<i>Half their difference</i>	13 25
<i>Their sum</i>	176 50
<i>Half their sum</i>	88 25
<i>Complement of altitude</i>	80 44
<i>Complement of declination</i>	90 00
<i>Their difference</i>	9 16
<i>Half their difference</i>	4 38

As S. of $\frac{1}{2}$ the diff. of the azi. and hour from noon

13 25	9.36555
-------	---------

is to S. of their $\frac{1}{2}$ sum
So is T. of $\frac{1}{2}$ the differ. of the } com. of alt. and com. of dec. }

88 25	9.99983
4 38	8.90872

18.90855

9.36555

to T. com. of $\frac{1}{2}$ the latitude

$19^{\circ} 14'$	9.54300
2	

Doubled is the com. of the which subtracted from

$38^{\circ} 28'$ Lat.
 90 00 gives

Latitude by observation

$51^{\circ} 32'$ as before

E

To

TO construe the problem geometrically, you must find the azimuth from the South, which subtracted from 180° leaves you the azimuth from the North; then with its complement taken from the half tangents, set from the centre A to C, draw the oblique circle Z C N; then set off the altitude of the sun, from the chords on the primitive circle from the horizon H H towards Z to cut the primitive circle in b and o, and draw the parallel of altitude b o, and where the parallel cuts the azimuth as at L; then thro' L and A draw the ecliptic E \mathcal{A} ; then from the ecliptic towards H, set the declination, if North; but if South, towards Z; then draw the equinoctial, and at right angles thereunto draw the poles P S, and draw the oblique circle P L S, and it is done; for P Z is the complement of latitude, and P H is the latitude of the place.

To

C H A P. V.

To correct the Going of the Watch by another Method.

To make requisite computations.

P R O B L E M I.

TO find the apparent time from an observed altitude of the Sun, the latitude of the place being known, as here, as we suppose, the latitude by dead reckoning.

S O L U T I O N.

If the latitude and the Sun's declination be of the same name, take the declination from 90° , but if the latitude and Sun's declination be of different names, add the declination to 90° , the difference or sum is the Sun's polar distance.

Find the co. latitude, and the Sun's co. altitude.

Add into one sum, the polar distance, co. latitude and co. altitude; take half the sum; find the difference between the half sum and the co. altitude.

Add into one sum, the arithmetical complement of the log. sine of the co. latitude, the arithmetical complement of the log. sine of the polar distance, the log. sine of half the sum, and the log. sine of the difference, take half this sum: this last half sum is the co. sine of an angle, which being doubled, is the Sun's horary angle. The horary angle turned into time, will give you the instant of observation from noon. If the Sun be rising, or on the East side of the meridian, take this time from twelve hours; and the remainder is the time of observation; but if the Sun be on the West of noon, this time is the instant of observation.

E X A M P L E I.

In latitude $51^\circ 32'$ North, by account, June 21, 1786, at 10 in the morning, by my watch, I observed the Sun's lower limb $53^\circ 31'$: require the L. time, and error in the watch?

Sun's

Sun's altitude	53° 31'	
× Semi-sub.	14	
Altitude of Sun corrected	53 45	
Co. altitude	36 15	
Co. latitude	38 28	
Co. declination	66 32	
<hr/>		
Polar distance	66° 32'	0.03749
Co. latitude	38 28	0.20617
Co. altitude	36 15	
<hr/>		
Sum	141 15	
<hr/>		
Half sum	70 37 30	9.97468
½ Sum Co. altitude	34 22 30	9.75174
<hr/>		
	Sum	19.97008
		19.97008
	75 3	9.98504

Doubled 150 6

converted into time gives 10 h. 0 m. 24" and 12 h. leaves 1 h. 59 m. 36": time when the observation was made 10 in the morning per watch, shew the watch 24" slow.

E X A M P L E II.

Being on the North sea January 9, 1785, I observed the Sun's altitude 1° 14' I found my watch exactly 8 in the morning: I require the true time of observation and error in the watch?—Rule as by former Rule.

1° 14'	51° 32'	22° 08'
88 46	38 28	112 08

C H A P. VI.

To find the Latitude without knowing the Sun's Declination; and if the Day of the Month be lost, how to know what Day the Observation is made.

THIS may be done in any latitude, whose complement is less than the Sun's declination on the same side of the line the place of observation is on; for the Sun will be twice upon the meridian in twenty-four hours, viz. above the pole at noon, and under the pole at midnight.

RULE.

R U L E.

To find the latitude without knowing the Sun's declination, take the Sun's altitude at noon, when above the pole, and at midnight, when under the pole; half their difference is the complement of the latitude of observation.

E X A M P L E.

June 21, 1786, I took the altitude of the Sun in Greenland, when on the meridian above the pole $33^{\circ} 28'$, and at midnight under the pole $13^{\circ} 28'$, what was the latitude of the place?

<i>Altitude above the pole</i>	$33^{\circ} 28'$
<i>Do. below the pole</i>	$13 \quad 28$
	<hr/>
<i>Half their difference</i>	$\frac{1}{2}) 20 \quad 00$
	<hr/>
<i>Complement of latitude</i>	$10 \quad 00$
<i>Latitude of observation</i>	$80 \quad 00$
	<hr/> <hr/>

To find the day of observation, and thereby know the day of the month, this is the RULE: add the two altitudes together, half their sum is the Sun's declination for the day of observation.

E X A M P L E.

In the year 1786, I took the Sun's altitude in Greenland, when on the meridian above the pole $33^{\circ} 28'$, and at midnight under the pole $13^{\circ} 28'$; what time in the year was the observation made?

<i>Sun's altitude above the pole</i>	$33^{\circ} .28'$
<i>Sun's altitude under the pole</i>	$13 \quad .28$
	<hr/>
<i>Sum</i>	$\frac{1}{2}) 46 \quad .56$
	<hr/>
<i>Half their sum shews the } day to be June 21st. }</i>	$23 \quad .28$
	<hr/> <hr/>

N. B. It is here supposed the two altitudes are taken in the same place; and likewise they are to be the corrected altitudes, if taken by an Hadley's Quadrant.

F

CHAP.

C H A P. VII.

The Method of finding the Longitude from the Observation of the angular Distance between the Moon and the Sun, or a fixed Star.

THE motion of the Moon being much quicker than any other celestial body, is the reason why its angular distance is much better adapted to discover small differences of time, than like observations made with any other body. The method of observing its place at sea is, that of measuring the angular distance between it and the Sun, or a fixed star. This being done, it is plain, if by means of an ephemeris, the time of Greenwich corresponding with the observed distance, be found the time at the place of observation; being likewise known, the difference between these two times being turned into degrees and minutes, will give the difference of longitude between Greenwich and place of observation.

The calculations in the ephemeris being supposed to be accurate, the chief difficulty of this method will consist in finding the corrections necessary to be applied to the observed distance, to give the true distance as it would appear if taken at the centre of the earth. For since the altitude of every celestial body, not in the zenith, is rendered apparently greater by refractory power of the atmosphere, and is likewise apparently diminished by the parallax, it scarcely ever happens that the observed distance is equal to the true distance; but the very great distance of fixed stars renders their parallax absolutely insensible; and the horizontal parallax of the Sun being about $8\frac{1}{2}$ seconds, is seldom considered in practice.

Because the quantity of refraction and parallax depends on the altitude, it is necessary, in order to obtain the quantities, that the altitudes of both the objects should be taken at the same time that the angular distance is measured. A set of observations can be taken by no less number than three persons.

To make the requisite Observations.

First, To find the apparent time at the place of observation: This is most conveniently done by taking one or more altitudes of the Sun, and noting the time by a good watch: from each observation, compute the time; the difference between this time, and the correspondent time, noted by the watch, will shew how much the watch is fast or slow.

The

The mean of several observations, in all cases where it can be had, is always to be preferred. The best time to take the Sun's altitude for the solution of this problem, is when the altitude changes quickest, and this is when the Sun bears East or West.

Secondly, To make the observation of distance: The three observers being in readiness with their instrument carefully adjusted, according as directed, and the watch being suspended near one of the observers, or put into a fourth person's hand, appointed to note the time, two of the observers must take the altitudes, while the third measures the distance; and take notice, that in all cases the convex or exterior well defined edge or limb of the moon, must be used or brought to the horizon, whether that edge uppermost or lower limb of the Moon.

In measuring the distance, the most obscure or least luminous of the two objects must be viewed directly, and the other must be brought, by reflection, into the apparent contact with it. In this case also, the well defined edge of the Moon must always be made use of for the contact, even though it should be necessary, for that purpose, to make the reflected image pass beyond the other. In the night time it will be found advantageous to turn down one or more of the green screens, in order to take off the glare of the Moon, which would otherwise prevent the star from being seen. As soon as the observer of distance has settled his instrument to the required angle, let him give notice to his assistants, who, that moment must read of the respective altitudes from their quadrants; at the same instant, the fourth observer, or one of the three, as previously settled, notes the time by the watch. These four particulars being wrote down with expedition, the same observations are to be again repeated in the same manner, and the sets respectively wrote beneath the others. After six or seven sets have been made, the mean of the whole must be taken, from whence the longitude must be found by computation. If the watch made use of here be a stop watch, the time will be more to be depended upon, because the watch may be stopped the instant the observer finishes his distance, and the watch may be set to the exact time again by another time-piece, before the observers again repeat the operation, which must be done as soon as convenient.

P R O B L E M I.

The apparent distance of the centre of the Moon, from the centre of the Sun or a fixed star, together with their respective apparent altitudes, to find the corrected distance as it would appear if beheld from the centre of the earth.

RULES.

R U L E S.

I. Find the respective co. altitudes; place beneath each other the apparent distance of the Sun or star's co. altitude, and the Moon's co. altitude. Find their sum, and half sum, and also the difference between sum and half sum of the Sun or star's co. altitude. Add together the ar. co. log. sine of the apparent distance, the ar. co. log. sine of the Moon's co. altitude, and the log. sines of the half sum, and of the difference. Half this sum, and it will be log. co. sine of an angle, which being doubled gives the angle at the Moon.

II. Find, as above, the sum and half the sum of the apparent distance, the Moon's altitude, the Sun or star's co. altitude: find also the difference between the half sum and the Moon's co. altitude; add together the ar. co. log. sine of the apparent distance, the ar. co. log. sine of the Sun or star's co. altitude, and the log. sines of half the sum, and of the difference; half this sum, and the half will be the log. co. sine of an angle, which being doubled, gives the angle at the Sun and star.

III. Then say, radius, sine co. Moon's altitude : : * horizontal parallax; parallax in altitude : from the parallax in altitude, take the refraction found in the Table of Refraction, corresponding to the Moon's altitude; the remainder is the error of the Moon's altitude.

IV. Radius : sine co. of angle at the Moon's : : error of the Moon's altitude : is first error in dist. which is to be added the apparent distance, if the angle at the Moon be obtuse, but otherwise subtract.

V. Radius to sine co. of the angle of at the Sun or star : : refraction corresponding to the Sun or star's altitude : second error in distance, which add to the apparent distance, if the angle of at the Sun or star be acute, otherwise subtract.

From the corrected distance, to find the longitude of the place observed in: seek, in the ephemeris, on the day of the month, for the two computed distances nearest the distance observed; find the difference between the two computed distances, which call the first difference; find also the difference between the earliest of the two computed distances, and the correct observed distance, which call the second difference: then say, as the first difference : second difference : : 3 hours : a proportion of time, which added to the time of the first of the two computed distances, gives the apparent time at Greenwich;

* The Moon's horizontal parallax is found in the Nautical Ephemeris, against the day of the month. Every other element used in this computation, besides the angles, ought to be taken from that work.

E X A M P L E.

Suppose the following observations be taken in latitude $34^{\circ} 17' N.$ and longitude by dead reckoning $13^{\circ} 56'$ West of Greenwich, height of the eye 18 feet: it is required to compute the true longitude from the same.

April 4th, 1767			Distance observed			Observed		Observed	
Time by watch			Q& nearest limbs			altitude of		altitude of	
						sun's low.		moon's low.	
						limb from		limb from	
						horizon of		the horiz.	
						the sea		of the sea	
						°		°	
h.	m.	s.							
4	47	14	73	41	53	22	50	80	17
4	50	11	73	43	55	22	12	80	36
4	55	26	73	47	33	21	6	81	9
<hr/>			<hr/>			<hr/>		<hr/>	
S. 14	32	51	221	13	21	66	8	242	2
<hr/>			<hr/>			<hr/>		<hr/>	
M. 4	50	57	73	44	27	22	3	80	41

The going of the watch must be ascertained from the method for correcting the same by the RULES foregoing. By such observation we here suppose it to be known that the watch is 22 m. 38 sec. too fast, therefore 4h. 50' 57"—22' 38" gives 4h. 28' 19" the apparent time of observation. Previous to the actual computation for clearing the distance, it will be necessary to reduce the several observations to the centre of the Sun and Moon: seek in the ephemeris for the semidiameters of the Sun and Moon for the time of observation: the semidiameter of the Sun is $16' 1''$, and that of the Moon for noon at Greenwich is $15' 22''$, and for midnight $15' 16''$: now the difference of time equivalent is $13^{\circ} 56'$ West of Greenwich, is about an hour, which added to the observed time $4\frac{1}{2}$ hours makes $5\frac{1}{2}$ hours for the time roughly estimated for Greenwich. The difference of the Moon's semidiameter for 12 hours, is six seconds; therefore $12 \text{ h.} :: 6'' : 5\frac{1}{2} \text{ h.} : 2\frac{1}{2}''$, which as the semidiameter is decreasing must be taken from $15' 22''$, and leaves $15' 19\frac{1}{2}''$ for the Moon's semidiameter at the time of observation. This is the Moon's semidiameter as it would be if it was seen from the centre of the earth. To $15' 19\frac{1}{2}''$ add $16''$ for the increasing arising from the Moon's altitude, and the correcting the semidiameter; rejecting the $\frac{1}{2}''$ will be $15' 35''$ to bring the observed distance of the nearer limbs of the Sun and Moon to the apparent distance of their centres, the semidiameter of each must be added: That is $73^{\circ} 44' 27'' + 16' 1'' + 15' 35'' = 74^{\circ} 16' 3'' =$ the apparent distance of the Sun and Moon's centres.

G

To

To find the apparent altitude of the Sun's centre, the semidiameter must be added, and the dip subtracted; that is $22^{\circ} 3' + 16' - 4' = 22^{\circ} 15' =$ the apparent altitude of the Sun : it is not necessary in the altitudes to proceed to seconds.

To find the apparent altitude of the Moon, the lower limb being found used, the semidiameter must be added, and the dip subtracted; that is $80^{\circ} 41' + 16' - 4' = 80^{\circ} 53'$; the apparent altitude of Moon. In like manner as the Moon's semidiameter was found for the time of observation, so also must the horizontal parallax. Now the horizontal parallax at noon $56' 24''$; and at midnight $56' 1''$, the difference $23''$. Therefore $12 \text{ h.} : 23'' :: 52 \text{ h. } 11''$, which subtract from $56' 4''$, because the parallax is decreasing leaves $56' 13''$, for the horizontal parallax at the time of observation. This expressed in minutes and decimal parts $56'.217$: with these data we proceed according to the problem.

<i>Sun's app. alt.</i>	$22^{\circ} .15'$
<i>com. of alt.</i>	$67 .45$
<i>Moon's app. alt.</i>	$80 .53$
<i>com. alt.</i>	$9 .07$

<i>App dis.</i>	$74^{\circ} .16'$
<i>Moon's co. alt.</i>	$9 .07$
<i>Sun's co. alt.</i>	$67 .45$
<i>Sum</i>	$151 .08$
<i>Half</i>	$75 .34$
<i>Diff.</i>	$7 .49$

<i>Arit. co. sine</i>	0.01658
<i>Arit. co. sine</i>	0.80012

<i>Sine</i>	9.98607
<i>Sine</i>	9.13355

	19.93632
	9.96816

	<i>Co. sine</i>	
	$21^{\circ} .40'$	
<i>Doubled</i>	$43 .20$	<i>= an angle at the Moon</i>
<i>Ap. dis.</i>	$74 .16$	<i>Ari. co. sine</i> 0.01658
<i>Sun's co. alt</i>	$67 .45$	<i>Ari. co. sine</i> 0.03360
<i>Moon's co. alt.</i>	$9 .07$	
<i>Sum</i>	$151 .08$	
<i>Half</i>	$75 .34$	9.98607
	$67 .27$	9.96223
		19.99848
	$3 .23$	<i>co. sine</i> 9.99924
<i>Doubled</i>	$6 .46$	<i>= angle at the Sun</i>

<i>As Radius</i>		10.00000
: S. C. \angle alt.	80° .53	9.19988
:: Horiz. parallax	56' .217	1.74987
		<hr/>
: Par. in alt.	8' .91	0.94975
Sub. ref. 15' 9" =	.15'	
	<hr/>	
Error of Moon's alt.	8 .76	
<i>As radius</i>	90 .00	10.00000
: S. C. ang. at \triangleright	43 .20	9.86176
:: Error \triangleright alt.	8' .76	0.94250
		<hr/>
Error in dif. which } must be sub.	6' .37	0.80426
<i>As radius</i>	90° .00	10.00000
: S. C. \angle at Sun	6 .46	9.99696
:: Ref. cor. to al. 2' 20" = 2	.333	0.36791
		<hr/>
: Second err. in dif. } which must be added }	2 .317	0.36487

Now $6' 37'' = 6' 22'' 12'''$ and $2' 317'' = 2' 19''$, whence the apparent distance $74^\circ 17' 3'' - 6' 22'' 11''' + 2' 19'' = 74^\circ 11' 59'' 48''' =$ corrected distance. By Lyon's Compendium, the correct distance comes out $74^\circ 11' 58''$ and by Mr. Dunthorne's Compendium it is $74^\circ 11' 59''$.

The same example by Gunter.

Radius : S. $74^\circ 16' :: 9^\circ 07' : S. 8^\circ 46'$.

S. $8^\circ 46' : S. 75^\circ 34' :: S. 7^\circ 49' : a$ fine opposite to which on the line of verfed fines stands $43\frac{1}{2}^\circ =$ the angle at the Moon.

Now,

Radius : S. $9^\circ 07' :: 56' 22'' : 8' 9'' =$ Par. in alt. from which take 15' refraction, and the remainder $8' 75''$, is the error of the Moon's altitude.

Again,

Radius : S. $74^\circ 16' :: S. 67^\circ 45' : S. 62^\circ 50' : S. 57^\circ 34' :: S. 66^\circ 27' a$ fine opposite to which on the verfed fines stands a point, which is rather to the left hand of the half division of the space between the beginning of the line, and the division of 10° ; we shall therefore call it $6^\circ =$ the angle at the Sun.

And,

Radius : S. C. $53\frac{1}{2}^\circ = S. 46\frac{1}{2}^\circ ::$ error of \triangleright alt. $8' 75'' : \text{first error of dist. } 6' 33'' = 6' 19'' 48'''$.

Radius

Radius : S. C. $6^\circ =$ sine 84° : refrac. in alt. \odot $2' 33''$: second error is dist.
 $2' 32'' = 2' 19'' 12''$.

Lastly,

$74^\circ 16' 3'' - 6' 19'' 48'' + 2' 19'' 12'' = 74^\circ 12' 02'' 24''$ corrected distance. The correct distance $74^\circ 11' 59'' 48''$, we will call $74^\circ 12'$ because the $48''$ may be taken as a whole second ; Therefore,

Distance by the ephem. at 3 hours	$73^\circ 1' 27''$
at 6 do.	$74^\circ 28' 50''$
Observed distance	$74^\circ 12' 00''$
First difference	$1^\circ 27' 23''$
Second difference	$1^\circ 10' 33''$

Now, $1^\circ 27' 23'' : 1^\circ 10' 33'' :: 3 \text{ h.} : 2 \text{ h. } 25' 19''$, which added to 3 h. gives $5 \text{ h. } 25' 19'' =$ the time at Greenwich.

The time at Greenwich	$5 \text{ h. } 25' 19''$
Time at ship	$4^\circ 28' 19''$
Difference of time	$57^\circ 00''$

gives $14^\circ 15'$ longitude, which is West, because the time at Greenwich does not proceed the time at the ship. If the distance, as given by Gunter, be used, the longitude will come out $14^\circ 16'$ West. The longitude thus found, is the longitude of the place of observation ; for the watch is here supposed to go true during the interval between the altitudes and distance.

N. B. If the Sun rises or falls quick, the observation of distance it will be convenient to compute the time directly from the mean altitude.

C H A P. VIII.

A new, concise, easy, and infallible Method to determine the Longitude at Sea, independent of the dead Reckoning, by one Person only, and no other Instrument but an Hadley's Quadrant well adjusted.

R U L E.

FIND in the ephemeris the time the Moon or any of the Planets' centres pass the meridian of Greenwich ; take the time by the watch, well regulated, by any of the methods before-mentioned in this book, when either the Moon

or any of the Planets are on the meridian of the place the longitude is desired; for that time reduced into motion, and proper allowance being made for the difference of miles making a degree of longitude, will reduce the meridians to a true departure between the two meridians, and then the longitude may be easily found, either by Mercator's or middle latitude sailing.

E X A M P L E I.

Suppose at Petersburg, in Russia, the Moon was taken when on the meridian, by the watch well regulated, and found it on the 6th of May, 1786, to be 6 h. 20 m. and that taken from 7 h. 28 m. the time the Moon passes Greenwich that day, leaves 1 h. 8 m. which being reduced into motion is 17° multiplied by 60 gives 1020, the true departure between Petersburg and London; and if the complement of middle latitude be taken between the two places, and run down in the Tables of Difference of Latitude and Departure, the longitude in the distance column opposite the departure, (when multiplied by 10, because the numbers are too large to find by inspection) will be 1780, that divided by 60 = $29^{\circ} 30'$ = which is too small by $00^{\circ} 49'$ but if a canon be stated as proper difference of latitude :: the meridian difference of latitude : departure to the difference of longitude, it will come out $30^{\circ} 19'$ the true longitude required?

<i>As proper dif. of latitude</i>	504	2.70243
: <i>Meridian dif. of latitude</i>	899	2.95376
: : <i>Departure</i>	1020	3.00860
<i>dif. of longitude</i>		

 5.96236

 2.70243

<i>True longitude</i>	1819	3.25993
<i>from London 610)181(9</i>	$30^{\circ} 10'$	

E X A M P L E II.

June 10, 1786, suppose the Moon was taken when on the meridian of the Lizard, and found it 11 h. 25 m. $16''$; now the Moon was on the meridian of Greenwich that day 11 h. 12'.

	11 h.	25'	16	on meridian of Lizard
<i>Sub.</i>	11	12		on meridian of Greenwich

 0 13 16 after Greenwich shews my ship to the West of Greenwich, that reduced into motion gives $3^{\circ} 19'$, which reduced into miles = 199; then by the aforesaid canon the longitude = $5^{\circ} 14'$ West from Greenwich.

H

EXAMPLE

E X A M P L E III.

Suppose the Moon be taken on the meridian of Barbadoes August 7th, 1786, 14h. 26m.

	h.	m.	s.
viz. Barbadoes	14	26	0
Greenwich on that day is	10	18	0
	<hr/>		
	4	08	0

This reduced into motion $48^{\circ} 14'$; this multiplied by 60' gives 2894 miles; the true departure between the Isle of Barbadoes and Greenwich, and by the canon afore-mentioned, the longitude from the Isle of Barbadoes to Greenwich is 3377 miles from the East end of the said island.

E X A M P L E IV.

The Moon was taken on the meridian of Cape St. John, in Newfoundland, September 27th, 1786, 5h. 59m. 8s.: what was the longitude of St. John from Greenwich?

	h.	m.	s.	
Cape St. John's	5	59	8	
Greenwich	3	39		the Moon was on
	<hr/>			
Meridian	2	20	8	difference of

Time reduced into motion is $35^{\circ} 2'$ by $60 = 2102$ miles per canon, the difference of longitude 3332 as was required, and by this new method it will not require on e tenth part the labour of the method of finding the distance of the Moon from the Sun or a fixed star.

N. B. A person expert in taking the latitude, can tell within three minutes when any heavenly body comes to the meridian; and by allowing three minutes, the departure may be truly found between one meridian and another, when the difference in miles that make a degree of longitude are properly applied: thus, if your place be in a less latitude than Greenwich, find by inspection what miles make a degree of longitude in each latitude, and add the difference to the difference of the time when reduced into motion, and it will be the true departure; but if the place be in a greater latitude, then subtract the difference, and the departure will be the true departure between the places required.

A TABLE

TABLE III.

TABLE II.

TABLE I.

OF THE DIPS.

OF THE DIPS.

OF REFRACTION.

~~TABLE III. OF THE DIPS. OF THE DIPS. OF THE DIPS.~~

A

T A B L E

O F

R E F R A C T I O N , &c.

~~TABLE I. OF REFRACTION. TABLE II. OF THE DIPS. TABLE III. OF THE DIPS.~~

Decorative flourish

For the LEAP YEARS
T A B L E S

1784, 1788, 1792, 1796, 1800

OF THE

SUN'S DECLINATION,

FOR

The LEAP YEARS, &c.

Decorative flourish

TABLE of the SUN's DECLINATION,

For the LEAP YEARS,

1784, 1788, 1792, 1796, 1800.

Days.	S.		S.		S.		N.		N.		N.		N.		N.		S.		S.		S.			
	Jan.		Feb.		March		April		May		June		July		August		Sept.		Oct.		Nov.		Dec.	
	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	
1	23	2	17	10	7	16	4	51	15	18	22	11	23	6	17	53	8	3	3	29	14	43	21	58
2	22	57	16	52	6	53	5	13	15	36	22	18	23	2	17	38	7	41	3	52	15	1	22	7
3	22	52	16	34	6	30	5	37	15	54	22	25	22	57	17	22	7	18	4	15	15	20	22	15
4	22	46	16	16	6	6	5	59	16	11	22	32	22	52	17	6	6	56	4	38	15	39	22	23
5	22	39	15	58	5	44	6	22	16	28	22	39	22	46	16	50	6	35	5	1	15	56	22	31
6	22	32	15	40	5	21	6	45	16	45	22	45	22	40	16	33	6	11	5	24	16	15	22	38
7	22	25	15	22	4	57	7	6	17	1	22	51	22	33	16	16	5	50	5	48	16	32	22	44
8	22	18	15	3	4	35	7	30	17	18	22	56	22	26	16	0	5	26	6	10	16	50	22	50
9	22	9	14	44	4	11	7	52	17	34	23	1	22	19	15	42	5	4	6	33	17	7	22	56
10	22		14	25	3	47	8	14	17	50	23	6	22	12	15	24	4	41	6	56	17	24	23	1
11	21	15	14	5	3	23	8	36	18	5	23	10	22	3	15	6	4	18	7	19	17	40	23	6
12	21	42	13	44	2	59	8	57	18	20	23	14	21	55	14	49	3	55	7	41	17	56	23	10
13	21	32	13	25	2	30	9	20	18	35	23	17	21	46	14	30	3	32	8	4	18	13	23	14
14	21	21	13	6	2	13	9	41	18	49	23	20	21	37	14	11	3	9	8	26	18	28	23	18
15	21	11	12	43	1	49	10	2	19	3	23	22	21	28	13	52	2	45	8	49	18	43	23	21
16	21	1	12	24	1	25	10	24	19	17	23	24	21	17	13	34	2	22	9	11	18	58	23	23
17	20	48	12	3	1	2	10	45	19	30	23	26	21	8	13	14	1	59	9	33	19	13	23	25
18	20	36	11	41		38	11	5	19	44	23	27	20	57	12	54	1	36	9	55	19	27	23	27
19	20	24	11	20		13	11	25	19	56	23	28	20	46	12	35	1	12	10	16	19	41	23	28
20	20	10	10	59	N.	9	11	47			23	28	20	34	12	15		50	10	38	19	55	23	29
21	19	58	10	38		33	12	6	20	9	23	29	20	23	11	54		26	10	59	20	8	23	29
22	19	44	10	16		57	12	27	20	21	23	29	20	11	11	35	S.	3	11	20	20	21	23	29
23	19	29	9	54	1	20	12	46	20	33	23	28	19	58	11	15		22	11	42	20	33	23	28
24	19	15	9	31	1	43	13	7	20	44	23	27	19	46	10	54		44	12	2	20	45	23	27
25	19	2	9	8	2	7	13	26	20	55	23	25	19	33	10	33	1	8	12	23	20	57	23	25
26	18	46	8	47	2	31	13	46	21	6	23	23	19	19	10	12	1	31	12	44	21	8	23	21
27	18	30	8	24	2	55	14	5	21	16	23	20	19	6	9	50	1	55	13	3	21	19	23	19
28	18	15	8	3	3	17	14	23	21	26	23	18	18	52	9	29	2	19	13	24	21	30	23	16
29	17	58	7	38	3	40	14	42	21	35	23	16	18	38	9	8	2	41	13	44	21	40	23	12
30	17	43			4	4	15		21	45	23	11	18	23	8	46	3	5	14	4	21	49	23	8
31	17	18			4	28			21	54			18	8	8	25			14	23		23		4

A TABLE of the SUN'S DECLINATION,

For the First after LEAP YEAR,

1785, 1789, 1793, 1797.

	S.		S.		S.		N.		N.		N.		N.		N.		S.		S.		S.			
Days	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.
1	22	59	16	54	7	22	4	45	15	14	22	8	23	7	17	57	8	8	3	23	14	37	21	56
2	22	53	16	39	6	59	5	8	15	32	22	16	23	3	17	41	7	46	3	46	14	57	22	4
3	22	47	16	21	6	36	5	31	15	50	22	23	22	58	17	26	7	24	4	9	15	16	22	13
4	22	41	16	3	6	13	5	54	16	6	22	30	22	53	17	9	7	2	4	32	15	34	22	21
5	22	34	15	44	5	50	6	17	16	24	22	37	22	47	16	54	6	30	4	56	15	52	22	29
6	22	27	15	26	5	26	6	39	16	41	22	43	22	41	16	37	6	17	5	19	16	11	22	36
7	22	19	15	7	5	4	7	2	16	57	22	49	22	35	16	20	5	55	5	42	16	28	22	43
8	22	11	14	44	4	40	7	24	17	14	22	55	22	28	16	3	5	32	6	5	16	46	22	49
9	22	2	14	29	4	17	7	47	17	30	23		22	21	15	45	5	9	6	28	17	2	22	55
10	21	53	14	10	3	53	8	9	17	45	23	5	22	14	15	28	4	46	6	50	17	19	23	
11	21	44	13	50	3	29	8	31	18	1	23	9	22	5	15	11	4	23	7	12	17	36	23	5
12	21	34	13	30	3	5	8	53	18	16	23	12	21	57	14	52	4		7	36	17	52	23	10
13	21	33	13	10	2	42	9	15	18	31	23	16	21	48	14	34	3	37	7	58	18	9	23	13
14	21	24	12	49	2	18	9	36	18	46	23	19	21	40	14	15	3	14	8	21	18	24	23	17
15	21	13	12	28	1	55	9	57	19		23	21	21	29	13	57	2	51	8	43	18	39	23	20
16	20	52	12	8	1	31	10	19	19	14	23	24	21	21	13	38	2	28	9	5	18	54	23	23
17	20	39	11	47	1	8	10	40	19	27	23	25	21	10	13	19	2	4	9	27	19	9	23	25
18	20	26	11	26		44	11		19	40	23	27	20	59	13		1	41	9	49	19	24	23	27
19	20	14	11	4		20	11	22	19	53	23	28	20	49	12	39	1	18	10	11	19	37	23	28
20	20		10	43	N	3	11	42	20	6	23	29	20	37	12	20		55	10	32	19	51	23	29
21	19	48	10	21		27	12	2	20	18	23	29	20	25	11	59		31	10	54	20	4	23	29
22	19	33	9	59		51	12	23	20	30	23	29	20	14	11	39		8	11	15	20	17	23	29
23	19	20	9	37	1	14	12	42	20	41	23	28	20	1	11	20	S	16	11	36	20	28	23	28
24	19	4	9	15	1	38	13	3	20	52	23	27	19	49	10	58		39	11	57	20	42	23	27
25	18	49	8	52	2	2	13	21	21	4	23	26	19	36	10	38	1	3	12	18	20	53	23	25
26	18	35	8	30	2	52	13	41	21	13	23	24	19	23	10	17	1	26	12	38	21	5	23	23
27	18	19	8	7	2	49	14		21	24	23	20	19	10	9	56	1	49	12	59	21	16	23	20
28	18	3	7	45	3	12	14	20	21	33	23	18	18	55	9	34	2	13	13	19	21	26	23	17
29	17	47			3	53	14	37	21	43	23	15	18	41	9	13	2	36	13	39	21	36	23	13
30	17	30			3	57	14	56	22	51	23	11	18	27	9	51	2	59	13	58	21	46	23	10
31	17	14			4	27		22				18	12	8	30				14	19			23	5

A TABLE of the SUN'S DECLINATION,

For the Second after LEAP YEAR,

1786, 1790, 1794, 1798.

	S.		S.		S.		N.		N.		N.		N.		N.		S.		S.		S.			
Days	Jan.		Feb.		March		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.	D.	M.
1	23	0	17	2	7	29	4	38	15	10	22	6	23	8	17	59	8	14	3	17	14	32	21	54
2	22	25	16	44	7	6	5	2	15	27	22	14	23	4	17	45	7	52	3	40	14	51	22	3
3	22	49	16	26	6	43	5	24	15	45	22	22	22	59	17	30	7	29	4	3	15	10	22	12
4	22	43	16	8	6	26	5	47	16	2	22	29	22	54	17	14	7	8	4	27	15	29	22	20
5	22	36	15	50	5	57	6	10	16	20	22	36	22	49	16	58	6	45	4	50	15	47	22	27
6	22	29	15	32	5	33	6	32	16	37	22	43	22	43	16	41	6	23	5	13	16	5	22	34
7	22	22	15	13	5	9	6	55	16	54	22	49	22	36	16	25	6	0	5	36	16	23	22	41
8	22	14	14	54	4	45	7	17	17	10	22	54	22	30	16	8	5	37	5	59	16	41	22	48
9	22	5	14	35	4	23	7	40	17	26	22	59	22	23	15	51	5	15	6	22	16	59	22	54
10	21	56	14	15	4	0	8	2	17	41	23	4	22	15	15	33	4	52	6	44	17	16	22	59
11	21	47	13	56	3	36	8	24	17	57	23	8	22	7	15	15	4	29	7	7	17	32	23	4
12	21	36	13	36	3	13	8	46	18	12	23	12	21	59	14	57	4	7	7	30	17	48	23	9
13	21	26	13	15	2	48	9	8	18	27	23	15	21	50	14	39	3	44	7	52	18	4	23	13
14	21	16	12	56	2	24	9	30	18	41	23	18	21	41	14	21	3	21	8	15	18	20	23	17
15	21	5	12	35	2	1	9	51	18	56	23	21	21	32	14	3	2	57	8	37	18	35	23	20
16	20	54	12	14	1	38	10	12	19	10	23	23	21	23	13	44	2	34	8	59	18	50	23	22
17	20	42	11	53	1	15	10	33	19	24	23	25	21	13	13	24	2	11	9	21	19	5	23	24
18	20	30	11	32		50	11	54	19	37	23	27	21	3	13	5	1	48	9	43	19	19	23	26
19	20	17	11	10		27	11	15	19	50	23	28	20	52	12	45	1	25	10	5	19	33	23	28
20	20	3	10	48		3	11	36	20	2	23	29	20	41	12	25	1	1	10	27	19	47	23	29
21	19	50	10	26	N	20	11	56	20	15	23	25	20	29	12	5		37	10	49	20	0	23	29
22	19	36	10	5		44	12	16	20	27	23	29	20	17	11	46		15	11	10	20	14	23	29
23	19	23	9	43	1	8	12	36	20	38	23	28	20	4	11	25	S	9	11	30	20	27	23	28
24	19	8	9	21	1	32	12	57	20	50	23	27	19	52	11	4		33	11	51	20	39	23	26
25	18	53	8	58	1	54	13	16	21	1	23	26	19	40	10	43		56	12	12	20	50	23	25
26	18	38	8	30	2	18	13	35	21	11	23	24	19	27	10	22	1	19	12	33	21	2	23	23
27	18	24	8	14	2	42	13	55	21	21	23	21	19	3	10	1	1	42	12	53	21	13	23	21
28	18	8	7	51	3	6	14	13	21	31	23	18	18	59	9	40	2	6	13	13	21	24	23	17
29	17	51			3	28	14	32	21	40	23	15	18	45	9	19	2	30	13	34	21	34	23	15
30	17	36			3	52	14	50	21	49	23	12	18	31	8	57	2	5	13	53	21	44	23	11
31	17	19			4	16			21	58			18	16	8	35			14	13			23	6

TABLE of the SUN'S DECLINATION,

For the Third after LEAP YEAR,

1787, 1791, 1795, 1799.

Days.	S.		S.		S.		N.		N.		N.		N.		N.		N.		S.		S.			
	Jan.		Feb.		March		April		May		June		July		August		Sept.		Oct.		Nov.		Dec.	
	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	D. M.	
1	23	2	17	5	7	34	4	33	15	5	22	4	23	7	18	5	8	19	3	10	14	27	21	52
2	22	56	16	48	7	11	4	56	15	23	22	12	23	5	17	49	7	58	3	34	14	47	22	1
3	22	51	16	30	6	48	5	19	15	41	22	20	23		17	34	7	36	3	57	15	6	22	9
4	22	45	16	13	6	25	5	42	15	59	22	27	22	55	17	18	7	14	4	20	15	25	22	17
5	22	38	15	54	6	1	6	5	16	16	22	34	22	50	17	2	6	52	4	44	15	43	22	25
6	22	31	15	36	5	38	6	28	16	33	22	40	22	44	16	45	6	29	5	6	16	1	22	32
7	22	24	15	17	5	15	6	50	16	50	22	46	22	38	16	29	6	7	5	29	16	19	22	39
8	22	16	14	58	4	52	7	12	17	6	22	52	22	31	16	12	5	44	5	52	16	37	22	45
9	22	7	14	39	4	28	7	35	17	22	22	57	22	24	15	55	5	21	6	15	16	54	22	51
10	21	58	14	20	4	5	7	57	17	38	23	2	22	17	15	37	4	58	6	38	17	11	22	57
11	21	49	14		3	51	8	19	17	53	23	7	22	9	15	20	4	36	7	1	17	28	23	2
12	21	39	13	40	3	18	8	41	18	8	23	11	22	1	15	2	4	13	7	24	17	44	23	7
13	21	29	13	20	2	54	9	3	18	23	23	14	21	53	14	43	3	50	7	46	18		23	11
14	21	18	13		2	30	9	25	18	38	23	18	21	44	14	25	3	27	8	9	18	16	23	15
15	21	8	12	42	2	7	9	46	18	52	23	21	21	34	14	6	3	4	8	32	18	32	23	18
16	20	56	12	19	1	43	10	8	19	7	23	23	21	25	13	47	2	41	8	54	18	47	23	21
17	20	45	11	50	1	19	10	29	19	20	23	25	21	15	13	28	2	17	9	16	19	2	23	24
18	20	33	11	37		56	10	50	19	34	23	27	21	4	13	9	1	54	9	38	19	16	23	26
19	20	20	11	15		32	11	11	19	47	23	28	20	53	12	50	1	30	10		19	31	23	27
20	20	8	10	54		8	11	31	20		23	29	20	42	12	30	1	7	10	22	19	44	23	28
21	20	57	10	32	N.	15	11	52	20	12	23	29	20	31	12	10		43	10	43	19	58	23	29
22	20	44	10	10		39	12	12	20	24	23	29	20	20	11	50		20	11	5	20	11	23	29
23	20	33	9	48	1	2	12	32	20	36	23	28	20	8	11	30	S.	4	11	26	20	23	23	28
24	19	13	9	26	1	26	12	52	20	47	23	28	19	56	11	10		27	11	46	20	36	23	27
25	18	58	9	4	1	50	13	12	20	58	23	27	19	43	10	48		51	12	7	20	47	23	26
26	18	43	8	42	2	14	13	31	21	9	23	25	19	30	10	27	1	14	12	28	20	59	23	24
27	18	27	8	19	2	37	13	50	21	19	23	22	19	16	10	6	1	37	12	48	21	11	23	22
28	18	12	7	56	3		14	9	21	29	23	20	19	2	9	45	2	2	13	9	21	21	23	19
29	17	55			3	24	14	28	21	38	23	17	18	49	9	24	2	24	13	29	21	32	23	16
30	17	38			3	47	14	46	21	47	23	13	18	34	9	2	2	48	13	48	21	42	23	12
31	17	21			4	10			21	56			18	20	8	41		14	8				23	8

TABLE of the SUN'S DECLINATION.

For the Third after LEAP YEAR.

1787, 1791, 1795, 1799.

Day	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	23° 27' 00"	22° 51' 00"	22° 00' 00"	20° 54' 00"	19° 54' 00"	18° 59' 00"	18° 09' 00"	17° 14' 00"	16° 14' 00"	15° 09' 00"	14° 00' 00"	12° 51' 00"
2	23° 26' 00"	22° 50' 00"	21° 59' 00"	20° 53' 00"	19° 53' 00"	18° 58' 00"	18° 08' 00"	17° 13' 00"	16° 13' 00"	15° 08' 00"	14° 00' 00"	12° 50' 00"
3	23° 25' 00"	22° 49' 00"	21° 58' 00"	20° 52' 00"	19° 52' 00"	18° 57' 00"	18° 07' 00"	17° 12' 00"	16° 12' 00"	15° 07' 00"	14° 00' 00"	12° 49' 00"
4	23° 24' 00"	22° 48' 00"	21° 57' 00"	20° 51' 00"	19° 51' 00"	18° 56' 00"	18° 06' 00"	17° 11' 00"	16° 11' 00"	15° 06' 00"	14° 00' 00"	12° 48' 00"
5	23° 23' 00"	22° 47' 00"	21° 56' 00"	20° 50' 00"	19° 50' 00"	18° 55' 00"	18° 05' 00"	17° 10' 00"	16° 10' 00"	15° 05' 00"	14° 00' 00"	12° 47' 00"
6	23° 22' 00"	22° 46' 00"	21° 55' 00"	20° 49' 00"	19° 49' 00"	18° 54' 00"	18° 04' 00"	17° 09' 00"	16° 09' 00"	15° 04' 00"	14° 00' 00"	12° 46' 00"
7	23° 21' 00"	22° 45' 00"	21° 54' 00"	20° 48' 00"	19° 48' 00"	18° 53' 00"	18° 03' 00"	17° 08' 00"	16° 08' 00"	15° 03' 00"	14° 00' 00"	12° 45' 00"
8	23° 20' 00"	22° 44' 00"	21° 53' 00"	20° 47' 00"	19° 47' 00"	18° 52' 00"	18° 02' 00"	17° 07' 00"	16° 07' 00"	15° 02' 00"	14° 00' 00"	12° 44' 00"
9	23° 19' 00"	22° 43' 00"	21° 52' 00"	20° 46' 00"	19° 46' 00"	18° 51' 00"	18° 01' 00"	17° 06' 00"	16° 06' 00"	15° 01' 00"	14° 00' 00"	12° 43' 00"
10	23° 18' 00"	22° 42' 00"	21° 51' 00"	20° 45' 00"	19° 45' 00"	18° 50' 00"	18° 00' 00"	17° 05' 00"	16° 05' 00"	15° 00' 00"	14° 00' 00"	12° 42' 00"
11	23° 17' 00"	22° 41' 00"	21° 50' 00"	20° 44' 00"	19° 44' 00"	18° 49' 00"	17° 59' 00"	17° 04' 00"	16° 04' 00"	14° 59' 00"	14° 00' 00"	12° 41' 00"
12	23° 16' 00"	22° 40' 00"	21° 49' 00"	20° 43' 00"	19° 43' 00"	18° 48' 00"	17° 58' 00"	17° 03' 00"	16° 03' 00"	14° 58' 00"	14° 00' 00"	12° 40' 00"
13	23° 15' 00"	22° 39' 00"	21° 48' 00"	20° 42' 00"	19° 42' 00"	18° 47' 00"	17° 57' 00"	17° 02' 00"	16° 02' 00"	14° 57' 00"	14° 00' 00"	12° 39' 00"
14	23° 14' 00"	22° 38' 00"	21° 47' 00"	20° 41' 00"	19° 41' 00"	18° 46' 00"	17° 56' 00"	17° 01' 00"	16° 01' 00"	14° 56' 00"	14° 00' 00"	12° 38' 00"
15	23° 13' 00"	22° 37' 00"	21° 46' 00"	20° 40' 00"	19° 40' 00"	18° 45' 00"	17° 55' 00"	17° 00' 00"	16° 00' 00"	14° 55' 00"	14° 00' 00"	12° 37' 00"
16	23° 12' 00"	22° 36' 00"	21° 45' 00"	20° 39' 00"	19° 39' 00"	18° 44' 00"	17° 54' 00"	16° 59' 00"	15° 59' 00"	14° 54' 00"	14° 00' 00"	12° 36' 00"
17	23° 11' 00"	22° 35' 00"	21° 44' 00"	20° 38' 00"	19° 38' 00"	18° 43' 00"	17° 53' 00"	16° 58' 00"	15° 58' 00"	14° 53' 00"	14° 00' 00"	12° 35' 00"
18	23° 10' 00"	22° 34' 00"	21° 43' 00"	20° 37' 00"	19° 37' 00"	18° 42' 00"	17° 52' 00"	16° 57' 00"	15° 57' 00"	14° 52' 00"	14° 00' 00"	12° 34' 00"
19	23° 09' 00"	22° 33' 00"	21° 42' 00"	20° 36' 00"	19° 36' 00"	18° 41' 00"	17° 51' 00"	16° 56' 00"	15° 56' 00"	14° 51' 00"	14° 00' 00"	12° 33' 00"
20	23° 08' 00"	22° 32' 00"	21° 41' 00"	20° 35' 00"	19° 35' 00"	18° 40' 00"	17° 50' 00"	16° 55' 00"	15° 55' 00"	14° 50' 00"	14° 00' 00"	12° 32' 00"
21	23° 07' 00"	22° 31' 00"	21° 40' 00"	20° 34' 00"	19° 34' 00"	18° 39' 00"	17° 49' 00"	16° 54' 00"	15° 54' 00"	14° 49' 00"	14° 00' 00"	12° 31' 00"
22	23° 06' 00"	22° 30' 00"	21° 39' 00"	20° 33' 00"	19° 33' 00"	18° 38' 00"	17° 48' 00"	16° 53' 00"	15° 53' 00"	14° 48' 00"	14° 00' 00"	12° 30' 00"
23	23° 05' 00"	22° 29' 00"	21° 38' 00"	20° 32' 00"	19° 32' 00"	18° 37' 00"	17° 47' 00"	16° 52' 00"	15° 52' 00"	14° 47' 00"	14° 00' 00"	12° 29' 00"
24	23° 04' 00"	22° 28' 00"	21° 37' 00"	20° 31' 00"	19° 31' 00"	18° 36' 00"	17° 46' 00"	16° 51' 00"	15° 51' 00"	14° 46' 00"	14° 00' 00"	12° 28' 00"
25	23° 03' 00"	22° 27' 00"	21° 36' 00"	20° 30' 00"	19° 30' 00"	18° 35' 00"	17° 45' 00"	16° 50' 00"	15° 50' 00"	14° 45' 00"	14° 00' 00"	12° 27' 00"
26	23° 02' 00"	22° 26' 00"	21° 35' 00"	20° 29' 00"	19° 29' 00"	18° 34' 00"	17° 44' 00"	16° 49' 00"	15° 49' 00"	14° 44' 00"	14° 00' 00"	12° 26' 00"
27	23° 01' 00"	22° 25' 00"	21° 34' 00"	20° 28' 00"	19° 28' 00"	18° 33' 00"	17° 43' 00"	16° 48' 00"	15° 48' 00"	14° 43' 00"	14° 00' 00"	12° 25' 00"
28	23° 00' 00"	22° 24' 00"	21° 33' 00"	20° 27' 00"	19° 27' 00"	18° 32' 00"	17° 42' 00"	16° 47' 00"	15° 47' 00"	14° 42' 00"	14° 00' 00"	12° 24' 00"
29	22° 59' 00"	22° 23' 00"	21° 32' 00"	20° 26' 00"	19° 26' 00"	18° 31' 00"	17° 41' 00"	16° 46' 00"	15° 46' 00"	14° 41' 00"	14° 00' 00"	12° 23' 00"
30	22° 58' 00"	22° 22' 00"	21° 31' 00"	20° 25' 00"	19° 25' 00"	18° 30' 00"	17° 40' 00"	16° 45' 00"	15° 45' 00"	14° 40' 00"	14° 00' 00"	12° 22' 00"
31	22° 57' 00"	22° 21' 00"	21° 30' 00"	20° 24' 00"	19° 24' 00"	18° 29' 00"	17° 39' 00"	16° 44' 00"	15° 44' 00"	14° 39' 00"	14° 00' 00"	12° 21' 00"

2 MA 67

A
T A B L E
OF THE
SECANTS LESS RADIUS;
OR, THE
ARITHMETICAL COMPLEMENT of the COMPLEMENT SINE,
TO
EVERY MINUTE of the QUADRANT.

A TABLE of NATURAL SINES AND SECANTS LESS RADIUS.

M	D. 0.		N. S. S. L. R.		D. 1.		N. S. S. L. R.		D. 2.		N. S. S. L. R.		M
	N. S.	S. L. R.			N. S.	S. L. R.			N. S.	S. L. R.			
0	0.00000	00000	00000	0.00000	1745	0.00007	99985	1.75814	3497	0.00026	99939	5.45718	60
1	29	000	99999	3.53627	774	007	984	5097	519	027	938	5358	59
2	58	000	999	23524	803	007	984	4391	548	027	937	5001	58
3	87	000	999	05915	832	007	983	3696	577	028	936	4646	57
4	116	000	999	2.93421	862	008	983	3012	606	028	935	4295	56
5	145	000	999	83730	891	008	982	2339	635	029	934	3946	55
6	175	0.00000	99999	2.75812	1920	0.00008	99982	1.71676	3664	0.00029	99933	1.43600	54
7	204	000	999	69118	949	008	981	1023	693	030	932	3257	53
8	233	000	999	63318	978	009	980	0379	723	030	931	2916	52
9	262	000	999	58203	2007	009	980	69745	752	031	930	2579	51
10	291	000	999	53627	036	009	979	9121	781	031	929	2243	50
11	320	000	999	49488	065	009	979	8505	810	032	927	1911	49
12	349	0.00000	99999	2.45709	2094	0.00010	99978	1.67897	3839	0.00032	99926	1.41581	48
13	378	000	999	42233	123	010	977	7298	868	033	925	1253	47
14	407	000	999	39015	152	010	977	6708	897	033	924	0928	46
15	436	000	999	36018	181	010	976	6125	926	034	923	0605	45
16	465	000	999	33216	211	011	976	5550	953	034	922	0285	44
17	495	001	999	30583	240	011	975	4982	984	034	921	39967	43
18	524	0.00001	99999	2.28100	2269	0.00011	99974	1.64422	4013	0.00035	99919	1.39657	42
19	553	001	998	25752	298	011	974	3869	042	036	918	9338	41
20	582	001	998	23525	327	012	973	3322	071	036	917	9026	40
21	611	001	998	21406	356	012	972	2783	100	037	916	8718	39
22	640	001	998	19385	385	012	972	2250	129	037	915	8411	38
23	669	001	998	17455	414	013	971	1724	158	038	914	8106	37
24	698	0.00000	99998	2.15607	2443	0.00013	99970	1.61204	4188	0.00038	99912	1.37804	36
25	727	001	997	13834	472	013	969	0690	217	039	911	7503	35
26	756	001	997	12130	501	014	969	0182	246	039	910	7205	34
27	785	001	997	10490	530	014	968	59680	275	040	909	6909	33
28	814	001	997	08912	560	014	967	9183	304	040	907	6615	32
29	844	002	996	07388	589	015	966	8694	333	041	906	6322	31
30	873	0.00002	99996	2.05916	2618	0.00015	99966	1.58208	4362	0.00041	99905	1.36032	30
31	902	002	996	04492	647	015	965	7728	391	042	904	5744	29
32	931	002	996	03113	676	016	964	7254	420	042	902	5457	28
33	960	002	995	01777	705	016	963	6784	449	044	901	5173	27
34	989	002	995	0048	734	016	963	6320	478	044	900	4890	26
35	1018	002	995	1.99221	763	017	962	5861	507	044	898	4600	25
36	1047	0.00002	99995	1.97998	2792	0.00017	99961	1.55406	4536	0.00045	99897	1.34330	24
37	076	003	994	96808	821	017	960	4956	565	045	896	4053	23
38	105	003	994	95650	85	018	959	4511	594	046	894	3777	22
39	134	003	994	94522	879	018	959	4070	623	046	893	3507	21
40	164	003	993	93422	908	018	958	3634	653	047	892	3231	20
41	193	003	993	9235	938	019	957	3201	682	048	890	2961	19
42	1222	0.00003	99993	1.91304	2967	0.00019	99956	1.52774	4711	0.00048	99889	1.32692	18
43	251	003	992	90282	995	019	955	2350	740	049	888	2425	17
44	280	004	992	89283	3025	020	954	1931	769	049	886	2159	16
45	309	004	991	88307	054	020	953	1515	798	050	885	1896	15
46	338	004	991	87353	083	021	952	1104	827	051	883	1633	14
47	367	004	991	86419	112	021	952	0696	856	051	882	1373	13
48	1396	0.00004	99990	1.85505	3141	0.00021	99951	1.50292	4885	0.00052	99881	1.31114	12
49	425	004	990	84609	170	022	950	49892	924	052	879	0856	11
50	454	005	989	83732	199	022	949	9496	943	053	878	0600	10
51	483	005	989	82872	228	023	948	9103	972	054	876	0346	9
52	513	005	989	82029	257	023	947	8713	5001	054	875	0093	8
53	542	005	988	81202	286	023	946	8317	030	055	873	29841	7
54	1771	0.00005	99988	1.80390	3316	0.00024	99945	1.47945	5059	0.00056	99872	1.29591	6
55	600	006	987	79593	345	024	944	7566	088	056	870	9342	5
56	629	006	987	78811	374	025	943	7190	117	057	869	9095	4
57	658	006	986	78042	403	025	942	6817	146	058	867	8849	3
58	687	006	986	77287	432	026	941	6448	176	058	866	8605	2
59	716	006	985	76554	461	026	940	6081	205	059	864	8362	1
M			D. 89.				D. 88.				D. 87.		M

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

D. 3.				D. 4.				D. 5.					
M	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	M
0	5234	0.00060	99863	1.28120	6976	0.00106	99756	1.15642	8716	0.00166	99619	1.05970	60
1	263	60	861	7880	7005	107	754	461	745	167	617	826	59
2	292	61	860	7641	034	108	752	282	774	168	614	683	58
3	321	62	858	7401	063	109	750	104	853	169	612	535	57
4	350	62	857	7166	092	109	748	4925	831	170	109	397	56
5	376	63	855	6931	121	110	746	748	860	171	607	254	55
6	5408	0.00064	99854	1.26697	7150	0.00111	99744	1.14571	8889	0.00172	99604	1.05113	54
7	437	64	852	6465	179	112	742	395	918	173	602	4971	53
8	466	65	850	6233	208	113	740	220	947	175	599	830	52
9	495	66	849	6003	237	114	738	045	976	176	596	690	51
10	524	66	847	5774	266	115	736	3872	9005	177	594	550	50
11	553	67	846	5546	295	116	734	699	034	178	591	411	49
12	5582	0.00068	99844	1.25320	7324	0.00117	99731	1.13256	9063	0.00179	99588	1.04272	48
13	611	68	842	5094	353	118	729	355	092	180	586	133	47
14	640	69	841	4870	382	119	727	184	121	181	583	3995	46
15	669	70	839	4647	411	120	725	013	150	183	580	857	45
16	698	71	838	4425	440	121	728	2844	179	184	578	720	44
17	727	71	836	4205	469	121	721	675	208	185	575	583	43
18	5756	0.00072	99834	1.23985	7498	0.00122	99719	1.12506	9237	0.00186	99572	1.03447	42
19	785	73	832	3766	527	123	716	338	266	187	570	311	41
20	814	74	831	3549	556	124	714	171	295	188	567	175	40
21	844	74	829	3333	585	125	712	005	324	190	564	040	39
22	873	75	827	3117	614	126	710	1839	353	191	562	2907	38
23	902	76	826	2903	643	127	708	674	382	192	559	771	37
24	5931	0.00077	99824	1.22690	7672	0.00128	99705	1.12510	9411	0.00193	99556	1.02637	36
25	960	77	822	2478	701	129	703	346	440	194	553	504	35
26	989	78	821	2267	730	130	701	183	469	196	551	371	34
27	6018	79	819	2057	759	131	699	020	498	197	548	238	33
28	047	80	817	1848	788	132	696	0858	527	198	545	106	32
29	076	80	815	1640	817	133	694	696	556	199	542	1974	31
30	6105	0.00081	99813	1.21432	7846	0.00134	99692	1.10536	9585	0.00200	99540	1.01843	30
31	134	82	812	1226	877	135	689	375	614	202	537	712	29
32	163	83	810	1021	904	136	687	216	642	203	534	581	28
33	192	83	808	0817	933	137	685	057	671	204	531	451	27
34	221	84	806	0614	962	138	683	09898	700	205	528	321	26
35	250	85	804	0412	991	139	680	740	729	207	526	192	25
36	6279	0.00086	99803	1.20211	8020	0.00140	99678	1.09583	9758	0.00208	99523	1.01063	24
37	308	87	801	0010	049	141	676	426	787	209	520	0934	23
38	337	87	799	19811	078	142	673	270	816	210	517	806	22
39	366	88	797	9612	107	143	671	115	845	212	514	678	21
40	395	89	795	9415	136	144	668	8960	874	213	511	550	20
41	424	90	793	9218	165	145	666	805	903	214	508	423	19
42	6453	0.00091	99792	1.19022	8194	0.00146	99664	1.08651	9932	0.00215	99506	1.00296	18
43	482	91	790	8827	223	147	661	498	961	217	503	170	17
44	511	92	788	8633	252	148	659	345	990	218	500	044	16
45	540	93	786	8440	281	149	657	193	10019	219	497	099918	15
46	569	94	784	8248	310	150	654	041	048	220	494	793	14
47	598	95	782	8056	339	152	652	7890	077	222	491	668	13
48	6627	0.00096	99780	1.17866	8368	0.00153	99649	1.07759	10106	0.00223	99488	0.99544	12
49	656	96	778	7676	397	154	647	589	135	224	485	419	11
50	685	97	776	7487	426	155	644	439	164	225	482	296	10
51	714	98	774	7299	455	156	642	260	192	227	479	172	9
52	743	99	772	7112	484	157	639	141	221	228	476	049	8
53	773	100	770	6925	513	158	637	6993	250	229	473	8926	7
54	6802	0.00101	99768	1.16739	8542	0.00159	99635	1.06846	10279	0.00231	99470	0.98804	6
55	831	102	766	6554	571	160	632	699	308	232	467	682	5
56	860	102	764	6370	600	161	630	552	337	233	464	560	4
57	882	103	762	6187	629	162	627	406	366	235	461	439	3
58	918	104	760	6004	658	163	625	260	395	236	458	318	2
59	947	105	758	5823	687	164	622	115	424	237	455	197	1
M	D. 86.				D. 85.				D. 84.				M

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

D. 6.			D. 7.			D. 8.							
M	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	M
0	10453	0.00239	99452	0.98077	12187	0.00325	99255	0.91411	13917	0.00425	99029	0.85644	60
1	482	240	449	7957	216	326	251	308	946	426	023	555	59
2	511	241	446	837	245	328	248	205	975	428	019	465	58
3	540	243	443	717	274	330	244	103	4004	430	015	376	57
4	569	244	440	598	302	331	240	001	033	432	011	286	56
5	597	245	437	48c	331	333	237	0899	061	434	006	197	55
6	10626	0.00247	99434	0.97361	10360	0.00334	99233	0.90798	14090	0.00435	99002	0.85109	54
7	655	248	431	243	389	336	230	696	119	437	8998	020	53
8	684	249	428	126	418	337	226	595	148	439	994	4931	52
9	713	251	424	008	447	339	222	494	177	441	990	843	51
10	742	252	421	6891	476	341	219	394	205	443	986	755	50
11	771	253	418	774	504	342	215	293	234	444	982	667	49
12	10800	0.00255	99415	0.96658	12533	0.00344	99211	0.90193	14263	0.00446	98978	0.84579	48
13	829	256	412	542	562	345	208	0093	292	448	973	492	47
14	858	258	409	426	591	347	204	89994	320	450	969	404	46
15	887	259	406	310	620	349	200	894	349	452	965	317	45
16	916	260	401	195	649	350	197	795	378	454	961	230	44
17	945	262	399	080	678	352	193	696	407	455	957	143	43
18	10973	0.00263	99390	0.95966	12706	0.00353	99189	0.89598	14436	0.00457	98953	0.84056	42
19	11002	264	393	851	735	355	186	499	464	459	948	3970	41
20	031	266	390	738	764	357	182	401	493	461	944	884	40
21	060	267	386	624	793	358	178	303	522	463	940	797	39
22	089	269	383	510	822	360	175	205	551	465	936	711	38
23	117	270	380	397	851	362	171	107	580	467	931	626	37
24	11146	0.00272	99377	0.95285	12880	0.00363	99167	0.89010	14608	0.00468	98927	0.83540	36
25	175	273	374	172	908	365	163	8913	637	470	923	455	35
26	205	274	370	060	937	367	160	816	666	472	919	369	34
27	234	276	367	4948	966	368	156	719	695	474	914	284	33
28	263	277	364	836	995	370	152	623	723	476	910	199	32
29	291	279	360	725	3024	371	148	526	752	478	906	114	31
30	11320	0.00280	99357	0.94614	13053	0.00373	99144	0.88430	14781	0.00480	98902	0.83030	30
31	349	282	354	503	081	375	141	334	810	482	897	2945	29
32	378	283	351	393	110	376	137	239	838	483	893	861	28
33	407	284	347	283	139	378	133	143	867	485	889	777	27
34	436	286	344	173	168	380	129	048	896	487	884	693	26
35	465	287	341	063	197	382	125	7953	925	489	880	609	25
36	11494	0.00289	99337	0.93954	13226	0.00383	99122	0.87858	14954	0.00491	98876	0.82526	24
37	523	290	334	845	254	385	118	764	982	493	871	442	23
38	552	292	331	736	283	387	114	669	5011	495	867	359	22
39	580	293	327	628	312	388	110	575	040	497	363	276	21
40	609	295	324	519	341	390	106	481	069	499	858	193	20
41	638	296	320	411	370	392	102	388	097	501	854	110	19
42	11667	0.00298	99317	0.93304	13399	0.00393	99098	0.87294	15126	0.00503	98849	0.82027	18
43	696	299	314	196	427	395	094	201	155	505	845	1945	17
44	725	301	310	089	456	397	091	108	184	506	841	863	16
45	754	302	307	2982	485	399	087	015	212	508	836	780	15
46	783	304	303	876	514	400	083	6922	241	510	832	698	14
47	812	305	300	769	543	402	079	829	270	512	827	617	13
48	11840	0.00307	99297	0.92663	13572	0.00404	99075	0.86737	15299	0.00514	98823	0.81535	12
49	869	308	293	558	600	405	071	645	327	516	818	453	11
50	898	310	290	452	629	407	067	553	356	518	814	372	10
51	927	311	286	347	658	409	063	461	385	520	809	291	9
52	956	313	283	242	687	411	059	370	414	522	805	210	8
53	985	314	279	137	716	412	055	278	442	524	801	129	7
54	12014	0.00316	99276	0.92052	13744	0.00414	99051	0.86187	15471	0.00526	98796	0.81048	6
55	043	317	272	1928	773	416	047	096	500	528	791	0967	5
56	071	319	269	824	802	418	043	006	529	530	787	887	4
57	100	320	265	720	831	419	039	5915	557	532	782	807	3
58	129	322	262	617	860	421	035	825	586	534	778	727	2
59	158	323	258	514	888	423	031	738	615	536	773	647	1
M													M
			D. 83.				D. 82.				D. 81.		

D. 83.

D. 82.

D. 81.

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

D. 9.				D. 10.				D. 11.							
M	N. S.	S.L.R.	N. S.	S.L.R.	N. S.	S.L.R.	N. S.	S.L.R.	N. S.	S.L.R.	N. S.	S.L.R.	M		
0	15643	0.00538	98769	0.80567	17365	1.00665	99481	0.76033	19081	0.00805	98163	0.71940	60		
1	672	540	764	487	393	667	476	5961	109	808	157	875	59		
2	710	542	760	408	412	669	471	890	138	810	152	810	58		
3	730	544	755	328	451	672	466	819	167	813	146	746	57		
4	758	546	751	249	479	674	460	747	195	815	140	681	56		
5	787	548	746	170	508	676	455	676	224	818	135	616	55		
6	15816	0.00550	98741	0.80091	17537	1.00678	98450	0.75605	19252	0.00820	98129	0.71552	54		
7	845	552	737	012	565	681	445	534	281	823	124	488	53		
8	873	554	732	79933	594	683	440	463	309	825	118	423	52		
9	902	556	728	855	623	685	435	393	338	828	112	359	51		
10	931	558	723	777	651	687	430	323	366	830	107	295	50		
11	959	560	718	698	680	690	425	252	395	833	101	231	49		
12	15988	0.00562	98714	0.79620	17708	1.00692	98420	0.75182	19423	0.00835	98096	0.71167	48		
13	6017	564	709	542	737	694	414	112	452	838	090	104	47		
14	056	566	704	465	766	696	409	042	481	840	084	040	46		
15	074	568	700	387	794	699	404	4972	509	834	079	0976	45		
16	103	571	695	309	823	701	399	902	538	845	073	913	44		
17	132	573	690	232	852	703	394	832	566	848	067	850	43		
18	16160	0.00575	98686	0.79155	17880	1.00706	98388	0.74763	19595	0.00850	98061	0.70786	42		
19	189	577	681	078	909	708	383	693	623	852	056	723	41		
20	218	579	676	001	937	710	378	624	652	855	050	660	40		
21	246	581	671	8924	966	712	373	555	680	858	044	597	39		
22	275	583	667	847	995	715	368	486	709	860	039	534	38		
23	304	585	662	771	8023	717	362	417	737	863	033	471	37		
24	16333	0.00587	98657	0.78694	18052	1.00712	98357	0.74348	19766	0.00865	98027	0.70409	36		
25	361	589	652	618	081	722	352	279	794	868	021	346	35		
26	390	591	648	542	109	724	347	210	823	870	016	284	34		
27	419	593	643	466	138	726	341	142	851	873	010	221	33		
28	447	596	638	390	166	729	336	073	880	876	004	159	32		
29	476	598	633	315	195	731	331	005	908	878	7998	097	31		
30	16505	0.00600	98629	0.78239	18224	1.00733	98325	0.73937	19937	0.00881	97992	0.70034	30		
31	533	602	624	164	252	736	320	869	965	883	978	69972	29		
32	562	604	619	088	281	738	315	801	994	886	981	910	28		
33	591	606	614	013	309	740	310	733	20022	888	975	849	27		
34	620	608	609	7938	338	743	304	665	051	891	969	787	26		
35	648	610	604	863	367	745	299	597	079	894	963	725	25		
36	16677	0.00612	98600	0.77789	18395	1.00748	98294	0.73530	20108	0.00896	97958	0.69664	24		
37	706	615	595	714	424	750	288	462	136	899	952	602	23		
38	734	617	590	639	452	752	283	395	165	901	946	541	22		
39	763	619	585	565	481	755	277	328	193	904	940	475	21		
40	792	621	580	491	509	757	272	261	222	907	930	418	20		
41	820	623	575	417	538	759	267	194	250	909	928	357	19		
42	16849	0.00625	98570	0.77343	18567	1.00762	98261	0.73127	20279	0.00912	97922	0.69296	18		
43	878	628	565	269	595	764	256	060	207	914	916	235	17		
44	906	630	561	195	624	767	250	2993	336	917	910	174	16		
45	935	632	556	122	652	769	245	927	364	919	905	113	15		
46	964	634	551	048	681	771	240	860	393	922	899	053	14		
47	992	636	546	6975	710	774	234	794	421	925	893	8992	13		
48	17021	0.00638	98541	0.76902	18738	1.00776	98229	0.72727	20450	0.00928	97887	0.68932	12		
49	050	641	536	829	767	779	223	661	478	930	881	871	11		
50	078	643	531	756	795	781	218	595	507	933	875	811	10		
51	107	645	526	683	824	783	212	529	535	936	869	750	9		
52	136	647	521	610	852	786	207	463	563	938	863	690	8		
53	164	649	516	537	881	788	201	398	592	941	857	630	7		
54	17193	0.00652	98511	0.76465	18910	1.00791	98196	0.72332	20620	0.00944	97851	0.68570	6		
55	222	654	506	393	938	793	190	266	649	946	845	510	5		
56	250	656	501	321	967	796	185	201	677	949	839	451	4		
57	279	658	496	248	995	798	179	136	706	952	833	391	3		
58	308	660	491	177	9024	800	174	070	734	954	827	331	2		
59	336	663	486	105	052	803	168	005	763	957	821	272	1		
M				D. 80.				D. 79.				D. 78.	M		

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

M	D. 12.		N. S.	S. L. R.	D. 13.		N. S.	S. L. R.	D. 14.		N. S.	S. L. R.	M
	N. S.	S. L. R.			N. S.	S. L. R.			N. S.	S. L. R.			
0	20791	0.00960	97815	0.68212	22495	0.01128	97437	0.64791	24192	0.01310	97030	0.61632	60
1	820	962	809	153	523	131	430	737	220	313	023	582	59
2	848	965	803	093	552	133	424	682	249	316	015	531	58
3	877	968	797	034	580	136	417	627	277	319	008	481	57
4	905	970	790	7975	608	139	411	573	305	322	001	430	56
5	933	973	784	916	637	142	404	519	333	325	6994	380	55
6	20962	0.00976	97778	0.67857	22665	0.01145	97398	0.64464	24361	0.01329	96987	0.61330	54
7	990	978	772	798	693	148	391	410	390	332	980	279	53
8	1019	981	766	739	722	151	384	356	418	335	973	229	52
9	047	984	760	681	750	154	378	302	446	338	966	179	51
10	076	987	754	622	778	157	371	248	474	341	959	129	50
11	104	989	748	563	807	160	365	194	503	344	952	079	49
12	21132	0.00992	97742	0.67505	22835	0.01163	97358	0.64140	24531	0.01348	96945	0.61029	48
13	161	995	735	446	863	166	351	086	559	351	937	0979	47
14	189	998	729	388	892	169	345	032	587	354	930	929	46
15	218	1000	723	330	920	172	338	3978	615	357	923	879	45
16	216	003	717	272	948	175	331	925	644	360	916	830	44
17	275	006	711	214	977	178	325	871	672	364	909	780	43
18	21303	0.01009	97705	0.67156	23005	0.01181	97318	0.63818	24700	0.01367	96902	0.60730	42
19	331	011	698	098	033	184	311	764	728	370	894	681	41
20	360	014	692	040	062	187	304	711	756	373	887	631	40
21	388	017	686	6982	090	190	298	658	784	377	880	582	39
22	417	020	680	925	118	193	291	605	813	380	873	533	38
23	445	022	673	867	146	196	284	551	841	383	866	483	37
24	21474	0.01025	97667	0.66810	23175	0.01199	97278	0.63498	24869	0.01386	96858	0.60434	36
25	502	028	661	752	203	202	271	445	897	390	851	385	35
26	530	031	655	695	231	205	264	392	925	393	844	336	34
27	559	033	648	638	260	208	257	340	953	396	837	287	33
28	587	036	642	580	288	211	251	287	982	399	829	238	32
29	616	039	636	523	316	214	244	234	5010	402	822	189	31
30	21644	0.01042	97630	0.66466	23345	0.01217	97237	0.63181	25038	0.01406	96815	0.60140	30
31	672	045	623	409	373	220	230	129	066	409	807	091	29
32	701	047	617	353	401	223	223	076	094	412	800	042	28
33	729	050	611	296	429	226	217	024	122	416	793	59994	27
34	758	053	604	239	458	229	210	2972	151	419	786	945	26
35	786	056	598	182	486	232	203	919	179	422	778	897	25
36	21814	0.01059	97592	0.66126	23514	0.01235	97196	0.62867	25207	0.01426	96771	0.59848	24
37	843	062	585	069	542	238	189	815	235	429	764	800	23
38	871	064	579	013	571	241	182	763	263	432	756	751	22
39	899	067	573	5957	599	244	176	711	291	435	749	703	21
40	928	070	566	900	627	247	169	659	320	439	742	654	20
41	956	073	560	844	656	250	162	607	348	442	734	606	19
42	21985	0.01076	97553	0.65788	23683	0.01254	97155	0.62555	25376	0.01445	96727	0.59558	18
43	2013	079	547	732	712	257	148	501	404	439	719	510	17
44	041	081	541	676	740	260	141	451	432	452	712	462	16
45	070	084	534	620	769	263	134	400	460	455	705	414	15
46	098	087	528	564	797	266	127	348	488	459	697	366	14
47	126	090	521	509	825	267	120	297	516	462	690	318	13
48	22155	0.01093	97515	0.65453	23853	0.01272	97113	0.62245	25545	0.01465	96682	0.59270	12
49	183	096	508	398	882	275	106	194	573	469	675	222	11
50	212	099	502	342	910	278	100	142	601	472	667	175	10
51	240	102	496	287	938	281	093	091	629	475	660	127	9
52	268	104	489	231	966	285	086	040	657	479	653	079	8
53	297	107	483	176	995	288	097	1989	685	482	645	032	7
54	22325	0.01110	97476	0.6512	24023	0.01291	97072	0.61938	25713	0.01485	96638	0.58984	6
55	354	112	470	066	051	294	065	887	741	489	630	937	5
56	382	116	463	011	079	297	058	836	769	492	623	889	4
57	410	119	457	4956	108	300	051	785	789	495	615	842	3
58	438	122	450	901	136	303	044	734	826	499	608	795	2
59	467	125	444	846	164	336	037	683	854	502	600	748	1
M													M

D. 77.

D. 76.

D. 75.

A TABLE of NATURAL SINES and SECANTS LESS RAD:US.

M	D. 15.				D. 16.				D. 17.				M
	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	
0	25882	0.01506	96593	0.58700	27564	0.01716	96126	0.55961	29237	0.01940	95630	0.53406	60
1	910	509	585	653	592	719	118	622	265	944	622	365	59
2	938	512	578	606	620	723	110	878	293	948	613	323	58
3	966	516	570	559	648	727	102	834	321	952	605	283	57
4	994	519	572	512	676	730	94	790	348	956	596	242	56
5	6022	523	555	465	704	734	86	747	376	960	588	200	55
6	26050	0.01526	96547	0.58418	27731	0.01738	96078	0.55703	29404	0.01964	95579	0.53159	54
7	079	529	540	372	759	741	070	650	432	968	571	118	53
8	107	533	532	325	787	745	062	615	460	971	562	077	52
9	135	536	524	278	815	749	054	572	487	975	554	036	51
10	163	540	517	232	843	752	046	528	515	979	545	2995	50
11	191	543	509	185	871	756	037	484	543	983	536	255	49
12	26219	0.01547	96502	0.58139	27899	0.01760	96029	0.55441	29571	0.01987	95528	0.52914	48
13	247	550	494	092	927	763	021	398	599	991	519	873	47
14	275	553	486	046	955	767	013	354	626	995	511	832	46
15	303	557	479	7999	983	771	005	311	654	999	502	790	45
16	331	560	471	953	8011	774	5997	267	682	2003	493	751	44
17	359	564	462	907	8039	778	989	224	710	007	485	710	43
18	26387	0.01567	96456	0.57860	28067	0.01782	95981	0.55181	29737	0.02011	95476	0.52670	42
19	415	571	448	814	095	785	972	138	765	014	467	625	41
20	443	574	440	768	123	789	964	095	793	018	459	589	40
21	471	578	433	722	150	793	956	052	821	022	450	548	39
22	500	581	425	676	278	796	948	008	849	026	441	508	38
23	528	585	417	630	206	800	940	4965	876	030	433	467	37
24	26556	0.01588	96410	0.57584	28234	0.01804	95931	0.54923	29904	0.02035	95424	0.52427	36
25	584	591	402	539	262	808	923	880	932	038	415	387	35
26	612	595	394	493	290	811	915	837	960	042	407	346	34
27	640	598	386	447	318	816	907	794	987	046	398	306	33
28	668	602	379	401	346	819	898	751	30015	050	389	266	32
29	696	605	371	356	374	823	890	708	043	054	380	226	31
30	26724	0.01609	96363	0.57310	28402	0.01826	95882	0.54666	30071	0.02058	95372	0.52186	30
31	752	612	355	265	429	831	874	623	098	062	363	146	29
32	780	616	347	219	457	834	865	581	126	066	354	106	28
33	808	619	340	174	485	838	857	538	154	070	345	066	27
34	836	623	332	128	513	841	849	496	182	074	337	026	26
35	864	627	324	083	541	845	841	453	209	078	328	1986	25
36	26892	0.01630	96316	0.57038	28569	0.01849	95832	0.54411	30237	0.02082	95319	0.51946	24
37	920	634	308	6992	597	853	824	368	265	086	310	906	23
38	948	637	301	947	625	856	816	326	292	090	301	867	22
39	976	641	293	902	652	860	807	284	320	094	293	827	21
40	7004	644	285	857	680	864	799	241	348	098	284	787	20
41	032	648	277	817	708	868	791	196	376	102	275	748	19
42	27060	0.01651	96269	0.56767	28736	0.01871	95782	0.54157	30403	0.02106	95266	0.51708	18
43	088	655	261	722	764	875	774	115	431	110	257	668	17
44	116	658	253	677	792	879	766	073	459	114	248	629	16
45	144	662	246	633	820	883	757	931	486	118	240	589	15
46	172	666	238	588	848	887	746	3989	514	122	231	550	14
47	200	669	230	543	875	890	740	947	542	126	222	510	13
48	27228	0.01673	96222	0.56498	28903	0.01894	95732	0.53905	30570	0.02130	95213	0.51471	12
49	256	676	214	454	931	898	724	863	597	134	204	432	11
50	284	680	206	409	959	902	715	822	625	139	195	393	10
51	312	683	198	365	987	906	707	780	653	143	186	353	9
52	340	687	190	320	9015	910	698	738	680	147	177	314	8
53	368	691	182	276	042	913	690	697	708	151	168	275	7
54	27396	0.01694	96174	0.56231	29070	0.01917	95681	0.53655	30736	0.02155	95159	0.51236	6
55	424	698	166	187	098	921	674	614	763	159	151	197	5
56	452	701	158	134	126	925	664	572	791	163	142	158	4
57	480	705	150	099	154	929	656	531	819	167	133	119	3
58	508	709	142	054	182	933	647	489	846	171	124	080	2
59	536	712	134	010	209	936	639	448	874	175	115	041	1

M D. 74. M D. 73. M D. 72. M

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

D. 18.				D. 19.				D. 20.					
M	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	M
0	30902	0.02179	95106	0.51002	32557	0.02433	94552	0.48736	34202	0.02701	93969	0.46595	60
1	929	183	097	0963	584	437	542	699	229	706	959	560	59
2	957	188	088	924	612	442	533	663	257	711	949	525	58
3	985	192	079	887	639	446	523	626	284	715	939	491	57
4	1012	196	070	847	667	450	514	589	311	720	929	456	56
5	040	200	061	808	694	455	504	553	339	724	919	422	55
6	31063	0.02204	95052	0.50769	32722	0.02459	94495	0.48516	34366	0.02729	93909	0.46387	54
7	095	208	043	731	749	464	485	480	393	734	899	353	53
8	123	212	033	692	777	468	476	443	421	738	889	318	52
9	151	216	024	653	804	472	466	406	448	743	879	284	51
10	178	221	015	615	832	477	457	371	475	748	869	249	50
11	206	225	006	576	859	481	447	334	503	752	859	215	49
12	31233	0.02239	94997	0.50538	32887	0.02485	94438	0.48298	34530	0.02757	93849	0.46181	48
13	261	233	988	570	914	490	428	262	557	762	839	147	47
14	289	237	979	461	942	494	418	226	584	766	829	112	46
15	316	241	970	423	969	499	409	189	612	771	819	078	45
16	344	246	961	385	997	503	399	153	639	776	809	043	44
17	372	250	952	346	3024	508	390	117	666	780	799	009	43
18	31399	0.02254	94943	0.50308	33051	0.02512	94380	0.48081	34694	0.02785	93789	0.45975	42
19	427	258	933	270	079	516	370	045	721	790	779	941	41
20	454	262	924	232	106	521	361	009	748	794	769	907	40
21	482	266	915	194	134	525	351	7973	775	799	759	873	39
22	510	271	906	156	161	530	342	937	803	804	748	839	38
23	537	275	897	118	189	534	332	901	833	808	738	805	37
24	31565	0.02279	94888	0.50080	33216	0.02539	94322	0.47865	34857	0.02813	93728	0.45771	36
25	593	283	878	042	244	543	313	821	884	818	718	737	35
26	620	287	869	004	271	547	303	798	912	822	708	703	34
27	648	292	860	49966	298	552	293	758	939	827	698	669	33
28	675	296	851	928	326	556	284	736	966	832	688	635	32
29	703	300	842	890	353	561	274	686	993	837	677	601	31
30	31730	0.02304	94832	0.49852	33381	0.02565	94264	0.47650	35021	0.02841	93667	0.45567	30
31	758	309	823	815	408	570	254	615	048	846	657	534	29
32	786	313	814	777	436	574	245	579	075	851	647	500	28
33	813	317	805	739	463	579	235	544	102	855	637	466	27
34	841	321	795	702	490	583	225	508	130	860	626	433	26
35	868	326	786	664	518	588	215	473	157	865	616	395	25
36	31896	0.02330	94777	0.49626	33545	0.02592	94206	0.47437	35184	0.02870	93606	0.45365	24
37	923	334	768	589	573	597	196	402	211	874	596	332	23
38	951	338	758	551	600	601	186	366	239	879	585	298	22
39	979	343	749	514	627	606	176	331	266	884	575	265	21
40	2006	347	740	477	655	610	167	295	293	889	565	231	20
41	034	351	730	439	682	615	157	260	320	893	555	198	19
42	32061	0.02355	94721	0.49402	33710	0.02619	94147	0.47225	35347	0.02898	93544	0.45164	18
43	089	360	712	365	737	624	137	189	375	903	534	131	17
44	116	364	702	327	764	628	127	154	402	908	524	097	16
45	144	368	693	290	792	633	118	119	439	913	514	064	15
46	171	372	684	253	819	637	108	084	456	917	503	031	14
47	199	377	674	216	846	642	098	049	483	922	493	4997	13
48	32227	0.02381	94665	0.49179	33874	0.02647	94088	0.47014	35511	0.02927	93483	0.44964	12
49	254	385	656	142	901	651	078	6979	538	932	472	931	11
50	282	390	646	104	929	656	068	994	565	937	462	898	10
51	309	394	637	067	956	660	058	908	592	941	452	864	9
52	337	398	628	030	983	665	049	874	619	946	441	831	8
53	364	403	618	8993	4011	669	039	839	647	951	431	798	7
54	32392	0.02407	94609	0.48957	34038	0.02674	94029	0.46804	35674	0.02956	93420	0.44765	6
55	419	411	599	920	065	678	019	769	701	961	410	732	5
56	447	416	590	883	093	683	009	734	728	965	400	699	4
57	474	420	580	846	120	688	3999	699	755	970	389	666	3
58	502	424	571	809	147	692	989	664	782	975	379	633	2
59	529	429	561	773	175	697	979	630	810	980	368	600	1
M	D. 71.				D. 70.				D. 69.				M

A TABLE of NATURAL SINES and SECANTS LESS RAD.US.

M	D. 21.				D. 22.				D. 23.				M
	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	
0	35837	0.02985	93358	0.44567	37461	0.03283	92718	0.42642	39073	0.03597	92050	0.40812	60
1	864	990	348	544	488	289	707	611	099	603	039	782	59
2	891	995	338	501	515	294	697	580	127	608	028	753	58
3	918	999	327	468	542	299	686	549	153	613	016	724	57
4	945	3004	316	436	569	304	675	518	180	619	005	695	56
5	073	009	306	403	595	309	664	486	207	624	1994	664	55
6	36000	0.03014	93293	0.44370	37622	0.03314	92653	0.42455	39234	0.03630	91982	0.40634	54
7	027	019	285	337	649	319	642	424	260	635	971	604	53
8	054	024	274	305	676	324	631	393	287	640	959	575	52
9	018	029	264	272	703	330	620	362	314	646	948	545	51
10	108	034	253	239	730	335	609	331	341	651	936	516	50
11	135	038	243	207	757	340	598	300	367	657	925	486	49
12	36162	0.03043	93232	0.44174	37784	0.03345	92585	0.42269	39394	0.03662	91914	0.40457	48
13	190	048	222	142	811	350	576	238	421	667	902	437	47
14	217	053	211	109	838	355	565	207	448	673	891	398	46
15	244	058	201	077	865	360	554	176	474	678	879	368	45
16	271	063	190	044	892	366	543	145	501	684	868	339	44
17	298	068	180	012	919	371	532	115	528	689	856	310	43
18	36325	0.03073	93169	0.43979	37946	0.03376	92521	0.42084	39555	0.03695	91845	0.40280	42
19	352	078	159	947	973	381	510	053	581	700	833	251	41
20	379	083	144	915	999	386	499	022	608	706	822	222	40
21	406	088	137	882	8026	392	488	1992	635	711	810	192	39
22	434	093	127	850	053	397	477	961	661	716	799	163	38
23	461	097	116	818	080	402	466	930	688	722	787	134	37
24	36488	0.03102	93106	0.43785	38107	0.03407	92455	0.41899	39715	0.03727	91775	0.40105	36
25	515	107	095	753	134	412	444	869	741	733	764	076	35
26	542	112	084	721	161	418	432	838	768	738	752	046	34
27	569	117	074	689	188	423	421	808	795	744	741	017	33
28	596	122	063	657	215	428	410	777	822	749	729	39988	32
29	623	127	052	623	241	433	399	747	848	755	718	959	31
30	36650	0.03132	92042	0.43592	38268	0.03438	92388	0.41716	39875	0.0376	91706	0.39930	30
31	677	137	031	560	295	444	377	686	902	766	694	901	29
32	704	142	020	528	322	449	366	655	928	771	685	872	28
33	731	147	010	496	349	454	355	624	955	777	671	843	27
34	751	152	2999	464	376	459	343	594	982	782	660	814	26
35	785	157	988	432	403	465	332	564	4008	788	648	785	25
36	36812	0.03162	92978	0.43401	38430	0.03470	92321	0.41533	40035	0.03793	91636	0.39756	24
37	839	176	967	369	456	475	310	503	062	799	625	727	23
38	867	172	956	337	483	480	299	473	083	804	613	698	22
39	894	177	945	305	510	486	287	443	115	810	601	669	21
40	921	182	935	273	537	491	276	412	142	815	560	641	20
41	948	187	924	241	564	496	265	382	168	821	578	612	19
42	36975	0.03192	92913	0.43210	38591	0.03502	92254	0.41352	40195	0.03826	91566	0.39583	18
43	7002	197	902	178	617	507	243	322	226	832	555	554	17
44	029	202	892	146	644	522	231	291	248	838	543	526	16
45	056	207	881	114	671	517	220	261	275	843	531	497	15
46	083	212	870	083	698	523	209	231	301	849	519	468	14
47	110	217	859	051	725	528	198	201	328	854	508	439	13
48	37134	0.03222	92849	0.43020	38752	0.03533	92186	0.41171	40355	0.03860	91496	0.39411	12
49	164	228	838	2988	778	539	175	141	381	865	484	382	11
50	191	233	827	956	805	544	164	111	408	871	472	354	10
51	218	238	816	225	832	549	152	081	434	877	461	325	9
52	245	243	805	895	859	555	141	051	461	882	449	296	8
53	272	248	794	862	886	560	130	021	488	888	437	269	7
54	37299	0.03253	92784	0.42831	38912	0.03566	92119	0.40991	40514	0.03893	91425	0.39239	6
55	326	258	773	799	939	571	107	961	541	899	414	211	5
56	353	263	762	768	966	576	096	931	567	905	402	182	4
57	380	268	751	736	993	581	085	902	594	910	390	154	3
58	407	273	740	705	9020	587	073	872	621	916	378	129	2
59	434	278	729	674	046	592	062	842	647	921	366	097	1
M			D. 68.				D. 67.				D. 66.		M

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

D. 24.				D. 25.				D. 26.								
M	N	S.	S.L.R.	N	S.	S.L.R.	N	S.	S.L.R.	N	S.	S.L.R.	N	S.	S.L.R.	M
0	40674	0.03927	91355	0.39069	42262	0.04272	90631	0.37405	43837	0.04634	89879	0.35816	60			
1	700	933	343	040	288	278	618	378	863	640	867	790	59			
2	727	938	331	012	315	284	606	351	880	646	854	764	58			
3	753	945	319	8984	341	280	594	324	916	652	841	738	57			
4	780	950	307	955	367	296	582	297	942	659	828	712	56			
5	806	955	295	927	394	302	569	270	968	665	816	687	55			
6	40833	0.03961	91283	0.38895	42420	0.04308	90557	0.37243	43994	0.04671	89803	0.35661	54			
7	860	966	272	871	446	314	545	216	4220	677	790	635	53			
8	885	972	260	842	473	320	532	189	046	682	777	609	52			
9	913	978	248	814	499	326	520	162	072	69	764	583	51			
10	939	983	236	786	525	332	507	135	098	696	752	557	50			
11	966	989	224	758	552	337	495	198	124	702	739	532	49			
12	40992	0.03995	91212	0.38730	42578	0.04343	90483	0.37082	44151	0.04708	89726	0.35506	48			
13	1019	4000	200	702	604	349	470	005	177	714	713	481	47			
14	045	006	188	674	631	355	458	028	203	721	700	455	46			
15	072	012	176	646	657	361	446	001	229	727	687	429	45			
16	098	018	164	618	683	367	433	6974	255	733	674	404	44			
17	125	023	152	580	709	373	421	948	281	739	662	378	43			
18	41151	0.04029	91140	0.38562	42736	0.04379	90408	0.36921	44307	0.04746	89649	0.35353	42			
19	178	035	128	534	762	385	396	894	333	752	636	327	41			
20	204	040	116	506	788	391	383	867	359	758	623	302	40			
21	231	046	104	478	815	497	371	841	385	764	610	276	39			
22	257	052	092	450	841	403	358	814	411	771	597	251	38			
23	284	058	080	422	867	409	346	787	437	777	584	225	37			
24	41310	0.04063	91068	0.38394	42894	0.04413	90334	0.36761	44464	0.04783	89571	0.35200	36			
25	337	069	056	366	920	421	321	734	490	789	558	174	35			
26	363	075	044	338	946	427	309	708	516	796	545	149	34			
27	399	080	032	311	972	433	296	681	542	802	532	123	33			
28	416	086	030	283	999	439	284	655	568	808	519	098	32			
29	443	092	008	255	3025	445	271	628	594	815	506	073	31			
30	41469	0.04098	90996	0.38227	43051	0.04451	90259	0.36602	44620	0.04821	89493	0.35047	30			
31	496	103	984	200	077	457	246	575	616	827	480	022	29			
32	522	109	972	172	104	463	233	549	672	833	467	4997	28			
33	549	115	960	144	130	469	221	522	698	840	454	971	27			
34	575	121	948	117	156	475	208	497	724	846	441	946	26			
35	602	127	936	089	182	481	196	469	750	852	428	921	25			
36	41628	0.04132	90924	0.38061	43209	0.04487	90183	0.36443	44776	0.04859	89415	0.34896	24			
37	655	138	912	034	235	493	171	417	802	865	402	870	23			
38	681	144	899	006	261	500	158	390	828	871	389	845	22			
39	707	150	887	7979	287	506	146	364	854	878	376	820	21			
40	734	156	875	951	313	512	133	338	880	884	363	795	20			
41	760	161	863	924	340	518	120	311	906	89	350	770	19			
42	41787	0.04167	90851	0.37896	43366	0.04524	90108	0.36285	44932	0.04897	89337	0.34745	18			
43	813	173	839	869	392	530	095	250	958	903	324	719	17			
44	840	179	826	841	418	536	082	233	984	910	311	694	16			
45	869	185	814	814	445	542	070	206	5010	916	298	669	15			
46	892	190	802	786	471	548	057	180	039	922	285	644	14			
47	919	196	780	759	497	554	045	154	062	929	272	619	13			
48	41945	0.04202	90778	0.37732	43523	0.04560	90032	0.36128	45088	0.04935	89259	0.34594	12			
49	972	208	766	704	549	566	019	102	114	941	245	569	11			
50	998	214	753	677	575	573	007	076	140	948	232	544	10			
51	2024	220	741	650	602	579	89994	350	166	954	219	519	9			
52	051	225	729	623	623	585	981	024	192	961	206	494	8			
53	077	231	717	595	645	591	968	5998	218	967	193	469	7			
54	42104	0.04237	90704	0.37568	43680	0.04597	89956	0.53972	45243	0.04973	89180	0.34444	6			
55	130	243	692	541	706	603	943	946	269	980	167	420	5			
56	156	249	680	514	733	609	930	920	295	986	153	395	4			
57	183	255	668	487	759	616	918	894	321	993	140	370	3			
58	209	261	655	459	785	622	905	868	347	999	127	345	2			
59	235	267	643	432	811	628	892	842	373	5005	114	320	1			
M	D. 65.				D. 64.				D. 63.				M			

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

D. 27.				D. 28.				D. 29.					
M	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	M
0	45399	0.05012	89101	0.34295	46947	0.05407	88295	0.32839	48481	0.05818	87462	0.31443	60
1	425	018	087	271	973	413	281	815	506	825	448	420	59
2	451	025	074	246	999	420	266	793	532	833	438	397	58
3	477	031	061	221	7024	427	254	768	557	839	420	375	57
4	503	038	048	296	050	433	240	744	583	846	405	352	56
5	529	044	035	172	076	440	226	720	608	853	391	329	55
6	45554	0.05051	89021	0.34147	47101	0.05447	88213	0.32697	48634	0.05860	87377	0.31306	54
7	580	057	008	122	127	454	199	672	659	867	363	284	53
8	606	064	8995	098	152	460	185	650	684	874	349	261	52
9	632	070	981	073	178	467	172	626	710	881	325	238	51
10	658	077	968	048	204	474	158	602	735	888	331	216	50
11	684	083	995	024	229	481	144	679	761	895	306	193	49
12	45710	0.05089	88942	0.33999	47255	0.05487	88136	0.43555	48786	0.05902	87292	0.31170	48
13	736	096	928	975	281	494	177	532	811	910	278	148	47
14	762	102	915	950	306	501	103	508	837	917	263	125	46
15	787	109	902	925	332	508	089	465	862	924	250	103	45
16	813	115	888	901	358	515	075	461	887	931	235	080	44
17	839	122	875	876	383	521	062	438	913	938	221	058	43
18	45865	0.05129	88862	0.33852	47409	0.05528	88048	0.32414	48938	0.05945	87207	0.31035	42
19	891	135	848	827	434	535	034	391	964	952	193	013	41
20	917	142	835	803	460	542	028	367	989	959	178	090	40
21	942	148	822	779	486	549	006	344	9014	966	164	968	39
22	978	155	808	754	511	555	7993	320	440	973	150	945	38
23	964	161	795	730	537	562	979	297	065	980	136	923	37
24	46020	0.05168	88782	0.33705	47562	0.05569	87956	0.32274	49090	0.05988	87121	0.30900	36
25	046	174	768	681	588	576	951	250	116	995	107	878	35
26	072	181	755	657	614	583	937	227	141	6002	093	856	34
27	097	187	741	632	639	590	923	204	166	009	079	833	33
28	123	194	728	608	665	596	909	180	192	016	063	811	32
29	149	201	715	584	690	603	896	157	217	023	050	788	31
30	46175	0.05207	88701	0.33559	47716	0.05610	87882	0.32134	49242	0.06030	87036	0.30766	30
31	201	214	688	535	741	617	868	110	268	037	021	744	29
32	226	220	674	511	767	624	854	087	293	045	007	721	28
33	252	227	661	487	793	631	840	064	318	052	6993	699	27
34	276	233	647	463	818	638	826	041	344	059	978	677	26
35	304	240	634	438	844	645	812	018	369	066	964	655	25
36	46330	0.05247	88602	0.33414	47869	0.05651	87798	0.31994	49394	0.06073	86949	0.30632	24
37	355	253	607	390	895	658	784	971	419	08	935	610	23
38	381	260	593	366	920	665	770	948	445	088	921	588	22
39	407	266	580	342	946	672	756	925	470	095	906	566	21
40	433	273	566	318	971	679	743	902	495	102	892	544	20
41	458	280	553	294	997	686	729	879	522	109	878	521	19
42	46484	0.05286	88539	0.33269	48022	0.05693	87715	0.31856	49546	0.06116	86863	0.30499	18
43	510	293	526	245	048	700	701	833	571	124	849	477	17
44	536	300	512	221	073	707	687	810	596	131	834	455	16
45	561	306	499	197	099	714	673	787	622	138	820	433	15
46	587	313	485	173	124	721	659	763	647	145	805	411	14
47	613	320	472	149	150	727	645	740	672	153	791	398	13
49	46639	0.05326	88458	0.33125	48175	0.05734	87631	0.31717	49697	0.06160	86777	0.30367	12
49	664	333	445	101	201	741	617	695	723	167	762	345	11
50	690	340	431	058	226	748	603	672	748	174	748	323	10
51	716	346	407	074	252	755	589	649	773	181	733	301	9
52	742	353	404	030	277	762	575	626	798	189	719	279	8
53	767	360	390	006	303	769	560	603	824	196	704	257	7
54	46793	0.05366	88377	0.32982	48328	0.05776	87546	0.31580	49849	0.06203	86690	0.30235	6
55	819	373	363	958	354	783	532	557	874	211	675	213	5
56	844	380	349	934	379	790	518	534	899	218	661	191	4
57	870	386	336	910	405	797	504	511	924	225	646	169	3
58	896	393	332	887	430	804	490	488	950	232	632	147	2
59	921	400	308	863	456	811	476	466	975	240	617	125	1
M	D. 62.				D. 61.				D. 60.				M

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

M	D. 30.			D. 31.			D. 32.			D. 33.			M
	N	S.	S.L.R.	N	S.	S.L.R.	N	S.	S.L.R.	N	S.	S.L.R.	
0	50000	0.06247	86603	0.30103	51504	0.06693	85717	0.28816	52992	0.07158	84835	0.27579	60
1	025	254	588	081	529	761	702	795	53017	166	789	559	59
2	056	262	573	059	554	709	687	774	041	174	774	539	58
3	076	264	559	037	579	716	672	753	066	182	759	519	57
4	101	276	544	016	604	724	657	732	061	190	743	498	56
5	126	283	530	29994	628	731	642	711	115	197	728	478	55
6	50151	0.06291	86515	0.29972	51653	0.06739	85627	0.28690	53140	0.07205	84713	0.27458	54
7	176	298	501	950	678	747	612	669	165	213	697	438	53
8	201	305	486	928	703	754	597	648	189	221	681	418	52
9	227	313	471	907	728	762	582	627	214	229	666	398	51
10	252	320	457	895	753	770	567	607	238	237	650	378	50
11	277	327	442	863	778	777	551	586	263	245	635	357	49
12	50302	0.06335	86427	0.29841	51803	0.06785	85536	0.28565	53288	0.07253	84619	0.27337	48
13	327	342	413	820	828	793	521	544	312	261	604	317	47
14	352	350	398	798	852	800	506	523	337	269	588	297	46
15	377	357	384	776	877	808	491	502	361	277	573	277	45
16	403	364	369	755	902	816	476	481	386	285	557	257	44
17	428	372	354	733	927	823	461	461	411	293	542	237	43
18	50453	0.06379	86340	0.29712	51952	0.06831	85446	0.28440	53435	0.07301	84526	0.27217	42
19	478	386	325	690	977	839	431	419	460	309	511	197	41
20	503	394	310	663	2002	846	416	398	484	317	495	177	40
21	528	401	295	647	026	854	401	378	509	325	480	157	39
22	553	409	281	625	051	862	385	367	534	333	464	137	38
23	578	416	266	604	076	869	370	336	558	341	448	117	37
24	50103	0.06423	86251	0.29582	52101	0.06877	85355	0.28315	43583	0.07349	84433	0.27098	36
25	628	431	237	561	126	885	340	295	607	357	417	078	35
26	654	438	222	539	151	892	325	274	632	365	402	058	34
27	679	446	207	518	175	900	310	253	656	373	386	038	33
28	704	453	192	496	200	908	294	233	681	381	370	018	32
29	729	461	178	475	225	916	279	212	705	389	355	26998	31
30	50754	0.06468	86163	0.29453	52259	0.06923	85264	0.28191	73730	0.07397	84339	0.26978	30
31	779	475	148	432	275	931	249	171	754	405	324	959	29
32	804	483	133	410	299	939	234	160	779	413	308	939	28
33	829	490	119	389	324	947	218	130	804	421	292	819	27
34	854	498	104	367	349	954	203	109	828	429	277	899	26
35	879	505	089	346	374	962	188	089	853	437	261	879	25
36	50904	0.06513	86074	0.29325	52399	0.06970	85173	0.28068	53877	0.07445	84245	0.26860	24
37	929	520	059	303	423	978	157	048	902	454	230	840	23
38	954	528	045	282	448	986	142	027	926	462	214	820	22
39	979	535	030	261	473	993	127	006	950	470	198	800	21
40	1004	543	015	239	598	7001	112	27986	975	478	182	781	20
41	029	550	000	218	522	009	096	966	54000	486	167	761	19
42	51054	0.06558	85985	0.29197	52547	0.07017	85081	0.27945	54024	0.07494	84151	0.26741	18
43	079	565	970	176	572	024	066	925	049	502	135	722	17
44	104	573	956	154	597	032	051	904	073	510	120	702	16
45	129	580	941	133	621	040	035	884	097	518	104	682	15
46	154	588	926	112	646	048	020	863	122	527	088	663	14
47	179	595	911	091	671	056	005	843	146	535	072	643	13
48	51204	0.06603	85896	0.29069	52696	0.07064	84989	0.27823	54171	0.07543	84057	0.26623	12
49	229	610	881	048	728	071	974	802	195	551	041	604	11
50	254	618	866	027	745	079	959	782	220	559	025	584	10
51	279	625	851	006	770	087	943	762	244	567	009	565	9
52	304	633	836	8985	794	095	928	741	269	575	83994	545	8
53	329	640	821	964	819	103	913	721	293	583	987	526	7
54	51354	0.06648	85806	0.28942	52844	0.07111	84897	0.27701	54317	0.07592	83962	0.26506	6
55	379	656	792	921	869	119	882	680	342	600	946	487	5
56	404	663	777	900	893	126	866	660	366	608	930	467	4
57	429	671	762	879	918	134	851	640	391	616	915	448	3
58	454	678	747	858	943	142	836	619	415	624	899	428	2
59	479	686	732	837	967	150	820	599	439	633	883	409	1
M													M

D. 59.

D. 58.

D. 57.

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

M	D. 33.		N.S.	S. L. R.	D. 34.		N. S.	S. L. R.	D. 35.		N. S.	S. L. R.	M
	N.S.	S. L. R.			N. S.	S. L. R.			N. S.	S. L. R.			
0	54464	0.07641	83867	0.26389	55919	0.08143	82974	0.25244	57358	0.08664	81915	0.24141	60
1	488	649	851	370	943	151	887	225	381	672	899	123	59
2	513	657	835	350	968	160	871	206	405	681	882	105	58
3	537	665	820	331	992	168	855	188	429	690	865	087	57
4	561	674	804	311	56016	177	839	169	453	699	848	069	56
5	586	682	788	292	040	185	822	150	477	708	832	051	55
6	54610	0.07690	83772	0.26273	56064	0.08194	82806	0.25132	57501	0.08717	81815	0.24033	54
7	635	698	756	253	088	202	790	113	524	726	798	015	53
8	659	707	740	234	112	211	773	094	548	734	781	23997	52
9	683	715	724	215	136	219	757	072	572	743	765	979	51
10	708	723	708	195	160	228	741	056	596	752	748	961	50
11	732	731	692	176	184	237	724	039	619	761	731	943	49
12	54756	0.07740	83676	0.26157	56208	0.08245	82708	0.25020	57643	0.08770	81714	0.23925	48
13	781	748	660	137	232	254	692	001	667	779	698	907	47
14	805	756	645	118	256	262	675	4983	691	788	680	889	46
15	829	765	629	099	280	271	659	964	715	797	664	871	45
16	854	773	613	079	305	280	643	946	738	806	647	854	44
17	878	781	597	060	329	288	626	927	762	815	631	836	43
18	54902	0.07789	83581	0.26041	56353	0.08297	82610	0.24909	57786	0.08824	81614	0.23818	42
19	927	798	565	022	377	305	593	890	809	833	597	800	41
20	951	806	549	003	401	314	577	872	833	842	580	782	40
21	975	814	533	5983	425	323	561	853	857	850	563	764	39
22	999	823	517	964	449	331	544	835	881	859	546	747	38
23	5024	831	501	945	473	340	528	816	905	868	530	729	37
24	55048	0.07830	83485	0.25926	56497	0.08349	82511	0.24798	57928	0.08877	81513	0.23711	36
25	072	848	469	907	521	357	495	779	952	886	496	693	35
26	097	856	453	887	545	366	478	761	976	895	479	676	34
27	121	864	437	868	569	375	462	742	999	904	462	658	33
28	145	873	421	849	593	383	446	724	8023	913	445	640	32
29	169	881	405	830	617	392	429	706	047	922	428	622	31
30	55194	0.07889	83389	0.25811	56641	0.08401	82413	0.24687	58070	0.08931	81412	0.23605	30
31	218	898	373	792	665	409	396	669	094	940	395	587	29
32	242	906	356	773	689	418	380	650	117	949	378	569	28
33	266	914	340	754	713	427	363	632	141	958	361	552	27
34	291	923	324	735	736	435	347	614	165	967	344	534	26
35	315	931	308	716	760	444	330	595	198	977	327	516	25
36	55339	0.07940	83292	0.25697	56784	0.08453	82314	0.24577	58212	0.08986	81310	0.23499	24
37	363	948	276	678	808	462	297	559	236	995	293	481	23
38	388	956	260	659	832	470	281	541	260	9004	276	463	22
39	412	965	244	640	856	479	264	522	283	013	259	446	21
40	436	973	228	621	880	488	248	504	307	022	242	428	20
41	460	982	212	602	804	496	231	486	330	031	225	410	19
42	55484	0.07990	83195	0.25583	56928	0.08505	82214	0.24467	58354	0.09040	81208	0.23393	18
43	509	998	179	564	952	514	198	449	378	049	191	375	17
44	533	8007	163	545	976	523	101	431	401	058	174	358	16
45	557	015	147	546	57000	531	165	413	425	067	157	340	15
46	581	024	131	507	024	540	147	399	449	076	140	323	14
47	605	032	115	488	047	549	131	376	472	085	123	305	13
48	55630	0.08041	83098	0.25469	57071	0.08558	82115	0.24358	58496	0.09094	81106	0.23288	12
49	654	049	082	451	095	567	098	340	519	104	089	270	11
50	678	058	066	432	119	575	082	322	543	113	072	253	10
51	702	066	005	413	143	584	065	304	567	122	055	235	9
52	726	075	034	394	167	593	048	286	590	131	038	218	8
53	750	083	017	375	191	602	032	267	614	140	021	200	7
54	55775	0.08092	83001	0.25356	57215	0.08611	82015	0.24249	58637	0.09149	81004	0.23183	6
55	799	100	2985	338	238	619	1999	231	661	158	80987	165	5
56	823	109	969	319	262	628	982	213	684	168	970	148	4
57	847	117	953	300	286	637	965	195	708	177	953	130	3
58	871	126	936	282	310	646	949	177	731	186	936	113	2
59	895	134	920	263	334	655	932	159	755	195	919	096	1
M	D. 56.				D. 55.				D. 54.				M

A TABLE of NATURAL SINES and SECANTS LESS RADIUS.

M	D. 36.				D. 37.				D. 38.				M
	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	N. S.	S. L. R.	
0	58779	0.09204	80902	0.23078	60181	0.09765	79864	0.22054	61566	0.10347	78801	0.21066	60
1	802	213	885	061	225	775	846	037	589	357	783	050	59
2	826	223	867	043	228	784	829	020	612	367	764	033	58
3	849	232	850	026	251	794	811	003	635	376	747	017	57
4	873	241	833	009	274	803	793	1987	658	386	729	001	56
5	896	250	816	2991	298	813	776	970	681	396	711	0985	55
6	58920	0.09259	80799	0.22974	60321	0.09822	79758	0.21953	61704	0.10406	78693	0.20969	54
7	943	269	782	957	344	832	741	937	726	416	676	953	53
8	967	278	765	939	367	841	723	920	749	426	658	937	52
9	990	287	748	922	390	851	796	903	772	436	640	921	51
10	9014	296	730	905	414	861	688	887	795	446	622	905	50
11	037	306	713	888	437	870	671	870	818	456	604	889	49
12	59061	0.09315	80696	0.22870	60460	0.09880	79653	0.21853	61841	0.10466	78586	0.20872	48
13	084	324	679	853	483	889	635	837	864	476	568	856	47
14	108	338	662	836	506	899	618	820	887	486	550	840	46
15	131	343	644	819	529	909	600	803	909	496	532	824	45
16	154	352	628	801	553	918	583	787	932	505	514	808	44
17	178	361	610	784	576	928	565	770	955	515	496	792	43
18	59201	0.09370	80593	0.22767	60599	0.09937	79547	0.21754	61978	0.10525	78478	0.20776	42
19	225	380	576	750	622	947	530	737	2001	535	460	760	41
20	248	389	558	732	645	957	512	720	024	545	442	744	40
21	272	398	541	715	668	966	494	704	046	555	424	728	39
22	295	408	524	698	691	976	477	687	069	565	405	712	38
23	318	417	507	681	714	986	459	671	092	575	387	696	37
24	59342	0.09426	80489	0.22664	60738	0.09995	79441	0.21654	62115	0.10585	78369	0.20681	36
25	365	435	472	647	761	10005	424	688	138	595	351	665	35
26	389	445	455	630	784	015	406	621	160	605	333	649	34
27	412	454	438	613	807	024	388	605	183	615	315	633	33
28	436	463	420	595	830	034	371	588	206	625	297	617	32
29	459	473	403	578	853	044	353	572	229	636	279	601	31
30	59482	0.09482	80386	0.22561	60876	0.10053	79335	0.21555	62251	0.10646	78261	0.20585	30
31	506	491	368	544	899	063	318	539	274	656	243	569	29
32	529	501	351	527	922	073	300	522	297	666	225	553	28
33	552	510	334	510	945	082	282	506	320	676	206	537	27
34	576	520	316	493	968	092	264	490	342	686	188	522	26
35	599	529	299	476	991	102	247	473	365	696	170	506	25
36	59622	0.09538	80282	0.22459	61015	0.10112	79229	0.21457	62388	0.10706	78152	0.20490	24
37	646	548	264	442	038	121	211	440	411	716	134	474	23
38	669	557	247	425	061	131	193	424	433	726	116	458	22
39	693	566	230	408	084	141	179	408	456	736	098	442	21
40	716	576	212	391	107	151	158	391	479	746	079	427	20
41	740	585	195	374	130	160	140	375	502	756	061	411	19
42	59763	0.09595	80178	0.22357	61153	0.10170	79122	0.21358	62524	0.10767	78043	0.20395	18
43	786	604	160	340	176	180	105	342	548	777	025	379	17
44	809	614	143	323	199	190	087	326	570	787	007	364	16
45	832	623	125	306	222	199	069	309	592	797	7988	348	15
46	856	632	108	289	245	209	051	293	515	807	970	332	14
47	879	642	091	273	268	219	033	277	638	817	952	316	13
48	59902	0.09651	80073	0.22256	61291	0.10229	79015	0.21261	62660	0.10827	77934	0.20301	12
49	926	661	056	239	314	239	8998	244	683	838	916	285	11
50	949	670	038	222	337	248	980	228	706	848	897	269	10
51	972	680	021	205	360	258	962	212	728	858	879	254	9
52	995	689	003	188	388	268	944	195	751	868	861	238	8
53	60019	699	79986	171	406	278	926	179	774	878	843	222	7
54	60042	0.09708	79968	0.22154	61429	0.10288	78908	0.21163	62796	0.10888	77824	0.20207	6
55	065	718	951	138	451	298	891	147	819	899	806	191	5
56	089	727	934	121	474	307	873	131	842	909	788	175	4
57	112	737	916	104	497	317	855	114	864	919	769	160	3
58	135	746	899	087	520	327	837	098	887	929	751	144	2
59	158	756	881	070	543	337	819	082	909	940	733	128	1
M				D. 53.				D. 52.				D. 51.	M

A TABLE OF NATURAL SINES AND SECANTS LESS RADII.

M	D. 39.			D. 40.			D. 41.			D. 42.			M
	N.S.	S.L.R.	N.S.	S.L.R.	N.S.	S.L.R.	N.S.	S.L.R.	N.S.	S.L.R.	N.S.	S.L.R.	
0	62932	1.10950	77715	0.30113	64279	0.11575	76004	0.19193	65606	0.12222	75441	0.18306	60
1	955	960	696	097	302	585	586	178	628	233	452	291	59
2	977	970	678	082	323	596	567	163	650	244	433	277	58
3	3000	980	660	066	346	606	548	148	672	255	414	262	57
4	022	991	641	050	368	617	530	133	694	266	395	248	56
5	045	1001	623	035	390	628	511	118	716	277	375	233	55
6	63068	0.11011	77605	0.20019	64412	0.11638	76492	0.19103	65738	0.12288	75356	0.18219	54
7	090	022	586	004	435	649	473	088	759	299	337	204	53
8	113	032	568	19988	457	660	455	073	781	310	318	190	52
9	135	042	550	973	479	670	436	058	803	321	299	175	51
10	158	052	530	957	501	681	417	043	825	332	280	161	50
11	180	063	513	942	524	692	398	028	847	343	261	146	49
12	63203	0.11073	77494	0.19926	64546	0.11702	76380	0.19093	65869	0.12354	75241	0.18132	48
13	225	083	476	911	568	713	361	8998	891	365	222	118	47
14	248	094	458	895	590	724	342	983	913	376	203	103	46
15	271	104	439	880	612	734	323	968	935	387	184	089	45
16	293	114	421	864	635	745	304	953	956	399	165	074	44
17	316	125	402	849	657	756	286	939	978	410	146	060	43
18	63338	0.11135	77384	0.19834	64679	0.11766	76267	0.18924	66000	0.12423	75126	0.18045	42
19	361	145	366	818	701	777	248	909	022	432	107	031	41
20	383	156	347	803	723	788	229	894	044	443	088	017	40
21	408	166	329	787	746	799	210	879	066	454	069	002	39
22	428	176	310	772	768	809	192	864	088	465	050	988	38
23	451	187	292	756	790	820	173	849	109	476	030	7974	37
24	63473	0.11197	77273	0.19741	64812	0.11831	76154	0.18834	66131	0.12487	75011	0.17959	36
25	496	207	255	726	834	842	135	820	153	499	4992	945	35
26	518	218	236	710	856	852	116	805	175	510	973	931	34
27	540	228	218	695	878	863	097	790	197	521	953	916	33
28	563	239	199	680	901	874	078	775	218	532	934	902	32
29	585	249	181	664	923	885	059	760	240	543	915	888	31
30	63608	0.11259	77162	0.19649	64945	0.11895	76041	0.18746	66262	0.12554	74896	0.17874	30
31	630	270	144	634	967	906	022	731	284	566	876	859	29
32	653	280	125	618	989	917	003	716	306	577	857	845	28
33	675	291	107	603	5011	928	5984	701	327	588	838	831	27
34	698	301	088	588	033	939	965	686	349	599	818	816	26
35	720	312	070	572	055	949	946	672	371	610	799	802	25
36	63742	0.11322	77151	0.19557	65077	0.11960	75927	0.18657	66393	0.12622	74780	0.17788	24
37	765	332	033	542	099	971	908	642	413	633	760	774	23
38	787	343	014	527	122	982	889	628	436	644	741	760	22
39	810	353	6996	511	144	993	870	613	458	655	722	745	21
40	832	364	977	496	166	2004	851	598	480	666	703	731	20
41	854	374	959	481	188	015	832	483	501	678	683	717	19
42	63877	0.11385	76940	0.19466	65210	0.12025	75813	0.18569	66523	0.12689	74664	0.17703	18
43	899	395	921	450	232	036	794	554	545	700	644	689	17
44	922	406	903	435	254	047	775	539	566	712	625	674	16
45	944	416	884	420	276	058	756	525	588	723	606	660	15
46	966	427	866	405	298	069	738	510	610	734	586	646	14
47	989	437	847	390	320	080	719	495	632	745	567	632	13
48	64011	0.11448	76828	0.19375	65342	0.12091	75700	0.18481	66653	0.12757	74548	0.17618	12
49	033	458	810	359	364	102	680	466	675	768	528	604	11
50	056	469	791	344	386	113	661	451	697	779	509	590	10
51	078	479	772	329	408	123	642	437	718	791	489	576	9
52	100	490	754	314	430	134	623	422	740	802	470	561	8
53	123	501	735	299	452	145	604	408	762	813	451	547	7
54	64145	0.11511	76717	0.19284	65474	0.12156	75585	0.18393	66783	0.12825	74431	0.17533	6
55	167	522	698	266	496	167	566	373	805	836	412	519	5
56	190	532	679	254	518	178	547	364	827	847	392	505	4
57	212	543	661	238	540	189	528	349	848	859	373	491	3
58	234	553	642	223	562	200	509	335	870	870	353	471	2
59	256	564	623	208	584	211	490	320	891	881	334	436	1

M

D. 50.

D. 49.

D. 48.

A TABLE OF NATURAL SINES AND SECANTS LESS RADII.

M	D. 42.			D. 43.			D. 44.			D. 45.			M
	N.	S.	S.L.R.	N.	S.	S.L.R.	N.	S.	S.L.R.	N.	S.	S.L.R.	
0	66913	0.12893	74314	0.17449	68200	0.13587	73135	0.16622	69466	0.14307	71934	0.15823	60
1	935	904	295	435	221	599	116	608	487	319	914	810	59
2	956	915	276	421	242	611	099	595	508	331	894	797	58
3	978	927	256	407	264	623	076	581	529	343	873	784	57
4	999	938	237	393	285	634	056	568	549	355	853	771	56
5	7021	950	217	379	306	646	036	554	570	368	833	758	55
6	67043	0.12961	74198	0.17365	68327	0.13658	73016	0.16541	69591	0.14380	71813	0.15745	54
7	064	972	178	351	349	670	2996	527	612	392	792	731	53
8	084	984	159	337	370	682	976	514	633	404	772	718	52
9	107	995	139	323	391	694	952	500	654	417	752	705	51
10	129	3007	120	309	412	705	937	487	675	429	732	692	50
11	151	018	100	295	433	717	917	473	696	441	711	679	49
12	67172	0.13030	74080	0.17281	68455	0.13729	72897	0.16460	69717	0.14453	71691	0.15666	48
13	194	041	061	267	476	741	877	446	737	466	671	653	47
14	215	053	041	253	497	753	857	433	758	478	650	640	46
15	237	064	022	239	518	765	837	419	779	490	630	627	45
16	258	076	002	225	539	777	817	406	800	503	610	615	44
17	280	087	3983	212	561	789	797	392	821	515	590	602	43
18	67301	0.13098	73963	0.17198	68582	0.13800	72777	0.16379	69842	0.14527	71569	0.15589	42
19	323	110	944	184	603	812	757	366	862	540	549	576	41
20	344	121	924	170	624	824	737	352	883	552	529	563	40
21	366	133	904	156	645	836	717	339	904	564	508	550	39
22	387	145	885	142	666	848	697	326	925	577	488	537	38
23	409	156	865	128	688	860	677	312	946	589	468	524	37
24	67430	0.13168	73846	0.17115	68709	0.13872	72657	0.16299	69966	0.14601	71447	0.15511	36
25	452	179	826	101	730	884	637	285	987	614	427	498	35
26	473	191	802	087	751	896	617	272	70008	626	406	485	34
27	495	202	787	073	772	908	597	259	029	639	386	472	33
28	516	214	767	059	793	920	577	245	049	651	366	460	32
29	538	225	747	045	814	932	557	232	070	663	345	447	31
30	67559	0.13237	73728	0.17032	68835	0.13944	72537	0.16219	70091	0.14676	71325	0.15434	30
31	580	248	708	018	857	956	517	205	112	688	305	421	29
32	602	260	688	004	878	968	497	192	132	701	284	408	28
33	623	272	669	6996	899	980	477	179	153	713	264	395	27
34	645	283	649	977	920	992	457	166	174	726	243	382	26
35	666	295	629	963	941	4004	437	152	195	738	223	370	25
36	67688	0.13306	73610	0.16949	68962	0.14016	72417	0.16139	70215	0.14750	71203	0.15377	24
37	709	318	590	935	983	028	397	126	236	763	182	344	23
38	730	330	570	922	9004	040	377	113	257	775	162	331	22
39	752	341	551	908	025	052	357	099	277	788	141	318	21
40	773	353	531	894	046	064	337	086	298	800	121	306	20
41	795	365	511	880	067	076	317	073	319	813	100	293	19
42	67816	0.13376	73491	0.16867	69083	0.14088	72297	0.16060	70339	0.14825	71080	0.15280	18
43	837	388	472	853	109	100	277	046	360	838	059	267	17
44	859	400	452	839	138	112	257	033	381	850	039	255	16
45	880	411	432	826	150	124	236	020	401	863	019	242	15
46	901	423	412	812	172	136	216	007	422	875	0998	229	14
47	923	435	393	798	193	149	196	5994	443	888	978	216	13
48	67944	0.13446	73373	0.16785	69214	0.14161	72176	0.15980	70463	0.14900	70957	0.15204	12
49	965	458	353	771	235	173	156	967	484	913	937	191	11
50	987	470	333	758	256	185	136	954	505	926	916	178	10
51	8008	482	314	744	277	197	116	941	525	938	896	165	9
52	029	493	294	739	298	209	095	928	546	951	875	153	8
53	051	505	274	717	319	221	075	915	567	963	855	140	7
54	68072	0.13517	73254	0.16703	69340	0.14234	72055	0.15902	70587	0.14976	70834	0.15127	6
55	093	528	234	689	361	246	035	808	608	988	813	115	5
56	115	540	215	676	382	268	015	875	628	5001	793	102	4
57	136	552	195	662	403	270	1995	862	649	014	772	089	3
58	157	564	175	649	424	282	974	849	670	026	752	077	2
59	179	575	155	635	445	294	954	836	690	039	731	064	1
											711	051	0

M

D. 47.

D. 46.

D. 45.

M

LOGARITHMIC SOLAR TABLES

OF

HALF ELAPSED TIME,

MIDDLE TIME,

AND

RISING,

For SIX HOURS,

To EVERY MINUTE and HALF MINUTE.

LOGARITHMIC SOLAR TABLES.

					H. O.				
M.	S.	H.E.T.	M. T.	R.	M.	S.	H.E.T.	M. T.	R.
0	30	2.66121	2.63982	4.527654	30	30	0.87717	4.42386	2.94650
1		36018	94085	0.297860	31		7015	3088	6007
1	30	18409	3.11694	0.33099	31	30	6324	3779	7454
2		05916	24187	58066	32		5644	4459	8820
2	30	1.96225	33878	77448	32	30	4976	5127	3.00164
3		88707	41796	03284	33		4317	5786	1488
3	30	1.81613	3.48490	1.06673	33	30	0.83669	4.46434	3.02792
4		75814	54289	18271	34		3030	7073	4077
4	30	0700	9403	28502	34	30	2401	7702	5342
5		66125	63978	37653	35		1780	8323	6590
5	30	1986	8117	45931	35	30	1169	8934	7819
6		58208	71895	53488	36		0567	9536	9082
6	30	1.54733	3.75370	1.60440	36	30	0.79973	4.50130	3.10227
7		1515	8588	6877	37		9387	0716	1406
7	30	48520	81583	72869	37	30	8809	1294	2570
8		5718	4385	8474	38		8239	1864	3718
8	30	3086	7017	83739	38	30	7677	2426	4850
9		0605	9498	8703	39		7122	2981	5969
9	30	1.38258	3.91845	1.93399	39	30	0.76574	4.53529	3.17072
10		6032	4071	7854	40		6033	4070	8162
10	30	3915	6188	2.02091	40	30	5499	4604	9238
11		1896	8207	6131	41		4972	5131	20301
11	30	29967	4.00136	9991	41	30	4451	5652	1351
12		8120	1983	13687	42		3937	6166	2389
12	30	1.26349	4.03754	2.17223	42	30	0.73429	4.56674	3.23414
13		4647	5456	20638	43		2926	7177	4427
13	30	3010	7093	3915	43	30	2430	7673	5428
14		1432	8617	7073	44		1940	8163	6418
14	30	19910	10193	30120	44	30	1455	8648	7396
15		8440	1663	3063	45		0976	9127	8363
15	30	1.17018	4.13085	2.35910	45	30	0.70503	4.59600	3.29320
16		5642	4461	8667	46		0034	60069	30266
16	30	4307	5796	41338	46	30	69571	0532	1202
17		3013	7090	3930	47		9113	0990	2128
17	30	1757	8346	6447	47	30	8660	1443	3044
18		0536	9567	8993	48		8212	1891	3950
18	30	1.09348	4.20755	2.51271	48	30	0.67769	4.62334	3.34847
19		8193	1910	3586	49		7330	2773	5734
19	30	7067	3036	5841	49	30	6806	3207	6613
20		5970	4133	8039	50		6466	3637	7482
20	30	4901	5202	60182	50	30	6041	4062	8343
21		3857	6246	2274	51		5620	4483	9195
21	30	1.02838	4.27265	2.64316	51	30	0.65204	4.64899	3.40039
22		1843	8260	6312	52		4791	5312	0875
22	30	0870	9233	8262	52	30	4383	5720	1702
23		0.99918	30185	70169	53		3978	6125	2522
23	30	8988	1115	2036	53	30	3578	6525	3334
24		8077	2026	3863	54		3181	6922	4138
24	30	0.97184	4.32919	2.75652	54	30	0.62789	4.67314	3.44935
25		6310	3793	7405	55		2400	7703	5724
25	30	5454	4649	9124	55	30	2014	8089	6507
26		4614	5489	80809	56		1632	8471	7282
26	30	3791	6313	2461	56	30	1254	8849	8050
27		2082	7121	4083	57		0879	9224	8811
27	30	0.92189	4.37914	2.85675	57	30	0.60508	4.69595	3.49566
28		1411	8692	7238	58		0140	9904	50314
28	30	0646	9457	8773	58	30	59775	70328	1056
29		89894	40209	90282	59		9414	0686	1791
29	30	9156	0947	1765	59	30	9056	1047	2520
30		8430	1673	3223	60		8700	1403	3243

LOGARITHMIC SOLAR TABLES.

H. I.

M.	S.	H.E.T.	M.T.	R.	M.	S.	H.E.T.	M.T.	R.
00	30	0.58348	4.71755	3.53959	30	30	0.41488	4.88615	3.88625
1		7999	2104	4670	31		261	842	9997
1	30	655	450	5375	31	30	036	9067	507
2		310	793	6074	32		0812	291	90234
2	30	6970	3133	767	32	30	590	513	498
3		633	470	7455	33		368	735	900
3	30	0.56298	4.73805	3.58137	33	30	0.41049	4.89954	3.91420
4		5966	4137	814	34		39930	90173	876
4	30	637	466	9486	34	30	713	390	2331
5		311	792	6052	35		497	606	782
5	30	4987	5116	813	35	30	282	821	3232
6		666	437	1469	36		069	1034	679
6	30	0.54347	4.75756	3.62120	36	30	0.38856	4.91247	3.94123
7		031	6072	766	37		646	457	566
7	30	3718	385	3407	37	30	436	667	5005
8		406	697	4043	38		227	876	443
8	30	097	7005	675	38	30	020	2083	878
9		2791	312	5302	39		7813	290	6311
9	30	0.52488	4.77615	3.65924	39	30	0.37609	4.92494	3.96742
10		186	917	9542	40		495	698	7170
10	30	1886	8217	7156	40	30	202	901	597
11		589	514	756	41		001	3102	8021
11	30	294	809	8369	41	30	6800	303	443
12		002	9101	969	42		602	501	862
12	30	0.50711	4.79392	3.69566	42	30	0.36404	4.93699	3.99280
13		423	680	70158	43		206	897	696
13	30	137	966	745	43	30	011	4092	4.00109
14		49852	80251	1329	44		5816	287	521
14	30	570	533	909	44	30	622	481	930
15		290	813	2485	45		430	674	1337
15	30	0.49012	4.21091	3.73057	45	30	0.35238	4.94865	4.01743
16		8736	367	625	46		047	5056	2146
16	30	462	641	4189	46	30	4858	245	547
17		189	914	750	47		669	434	947
17	30	7919	2184	5307	47	30	482	621	3344
18		650	453	860	48		296	807	740
18	30	0.47883	4.82720	3.76409	48	30	0.34110	4.95993	4.04134
19		119	984	955	49		3925	618	526
19	30	6856	3247	7498	49	30	742	361	916
20		595	518	8037	50		559	544	5304
20	30	335	768	573	50	30	378	725	690
21		077	4026	9105	51		197	906	6074
21	30	0.45822	4.84281	3.79634	51	30	0.33017	4.97085	4.06457
22		567	536	80159	52		2839	264	838
22	30	315	788	682	52	30	661	442	7217
23		064	5039	1201	53		485	618	595
23	30	4815	288	717	53	30	309	794	970
24		567	536	2230	54		134	969	8344
24	30	0.44321	4.85782	3.82739	54	30	0.31960	4.98143	4.08716
25		077	6026	3246	55		787	316	9087
25	30	3834	269	749	55	30	614	489	456
26		593	510	4250	56		443	660	823
26	30	353	750	748	56	30	272	831	10188
27		114	989	5242	57		103	9200	552
27	30	0.42877	4.87226	3.85734	57	30	0.30934	4.99169	4.10915
28		643	460	6223	58		766	337	1275
28	30	409	694	709	58	30	599	504	634
29		176	927	7192	59		432	670	992
29	30	1945	8158	672	59	30	268	835	2343
30		716	387	8150	60		103	5 00000	702

LOGARITHMIC SOLAR TABLES.

H. II.

M	S.	H.E.T.	M. T.	R.	M.	S.	H.E.T.	M. T.	R.
0	30	0.29939	5.00164	4.13055	30	30	0.21432	5.08671	4.31801
1		776	327	406	31		309	794	2079
1	30	614	489	706	31	30	187	916	356
2		453	650	4104	32		066	9037	631
2	30	293	810	451	32	30	0945	158	906
3		133	970	791	33		824	279	3180
3	30	0.28974	5.01129	4.15140	33	30	0.20704	5.09399	4.33453
4		816	287	483	34		585	518	724
4	30	659	444	824	34	30	466	637	995
5		502	601	6113	35		348	755	4265
5	30	349	757	501	35	30	230	873	534
6		191	912	838	36		113	990	802
6	30	0.28037	5.02066	4.17173	36	30	0.19996	5.10107	4.35069
7		7884	219	507	37		880	223	335
7	30	731	372	839	37	30	764	339	601
8		579	524	8171	38		649	454	865
8	30	428	675	500	38	30	534	569	6128
9		277	826	828	39		420	683	391
9	30	0.27127	5.02976	4.19156	39	30	0.19306	5.10797	4.36652
10		6978	3125	482	40		193	910	913
10	30	830	275	608	40	30	081	1022	7173
11		682	421	20129	41		8968	135	432
11	30	535	568	451	41	30	857	246	690
12		389	714	771	42		746	357	948
12	30	0.26244	5.03859	4.21091	42	30	0.18635	5.11468	4.38204
13		099	4004	409	43		525	578	459
13	30	5955	148	725	43	30	415	668	714
14		811	292	2041	44		306	797	968
14	30	668	435	355	44	30	197	906	9221
15		526	577	668	45		089	2014	473
15	30	0.25385	5.04718	4.22980	45	30	0.17981	5.12122	4.39725
16		244	859	3290	46		874	229	975
16	30	104	999	599	46	30	767	336	40225
17		4964	5139	907	47		660	443	474
17	30	825	278	4214	47	30	554	549	722
18		687	416	520	48		449	654	969
18	30	0.24550	5.05553	4.24825	48	30	0.17344	5.12759	4.41215
19		413	690	5128	49		239	864	461
19	30	276	827	430	49	30	135	968	706
20		141	962	731	50		023	3071	950
20	30	006	6097	6031	50	30	6928	175	2193
21		3871	232	330	51		820	277	435
21	30	0.23738	5.06365	4.26628	51	30	0.16724	5.13379	4.42677
22		605	498	924	52		622	481	918
22	30	472	631	7220	52	30	520	583	3158
23		340	763	514	53		419	684	398
23	30	209	894	807	53	30	319	784	636
24		078	7025	8099	54		219	884	874
24	30	0.22948	5.07155	4.28391	54	30	0.16119	5.13984	4.44111
25		819	284	681	55		020	4083	348
25	30	690	413	969	55	30	5921	182	4588
26		561	542	9257	56		823	280	818
26	30	433	670	544	56	30	725	378	5052
27		306	797	830	57		628	475	286
27	30	0.22180	5.07923	4.30115	57	30	0.15530	5.14573	4.45518
28		054	8049	398	58		434	669	750
28	30	1928	175	684	58	30	338	765	981
29		803	300	1963	59		242	861	6212
29	30	679	424	143	59	30	146	975	442
30		555	548	523	60		051	5052	671

LOGARITHMIC SOLAR TABLES.

H. III.

M	S.	H.E.T.	M. T.	R.	M.	S.	H.E.T.	M. T.	R.
0	30	0.14957	5.15146	4.46899	30	30	0.09981	5.20122	4.59436
1		863	230	7127	31		909	194	627
1	30	769	334	354	31	30	837	266	818
2		676	427	580	32		765	338	60008
2	30	583	520	806	32	30	694	409	198
3		490	613	8031	33		623	480	387
3	30	0.14398	5.15705	4.48255	33	30	0.09552	5.20551	4.60576
4		307	796	479	34		482	612	764
4	30	215	888	701	34	30	412	691	952
5		124	979	924	35		343	760	1139
5	30	034	6069	9145	35	30	273	830	326
6		3944	159	366	36		204	899	512
6	30	0.13854	5.16249	4.49586	36	30	0.09136	5.20967	4.61698
7		765	338	806	37		067	1036	883
7	30	676	427	50025	37	30	8999	104	2068
8		587	516	243	38		931	172	252
8	30	399	604	461	38	30	864	239	436
9		411	692	677	39		797	306	619
9	30	0.13324	5.16779	4.50894	39	30	0.08730	5.21373	4.62802
10		237	866	1109	40		664	439	984
10	30	150	953	324	40	30	597	506	3166
11		064	7039	539	41		531	572	347
11	30	2978	125	753	41	30	466	637	528
12		893	210	966	42		401	702	708
12	30	0.12807	5.17297	4.52178	42	30	0.08336	5.21767	4.63888
13		723	380	390	43		271	832	4068
13	30	638	465	601	43	30	207	896	246
14		554	549	812	44		143	960	425
14	30	471	632	3022	44	30	079	2024	603
15		387	716	231	45		015	088	780
15	30	0.12305	5.17798	4.53440	45	30	0.07952	5.22151	4.64957
16		222	881	648	46		889	214	5134
16	30	140	963	856	46	30	827	276	310
17		058	8045	4063	47		865	338	486
17	30	1977	126	269	47	30	703	400	661
18		895	208	475	48		641	462	836
18	30	0.11815	5.18288	4.54680	48	30	0.07579	5.22524	4.66010
19		734	369	885	49		518	585	184
19	30	654	449	5089	49	30	458	645	357
20		575	528	293	50		397	706	530
20	30	495	608	496	50	30	337	766	702
21		416	687	698	51		277	826	874
21	30	0.11338	5.18765	4.55900	51	30	0.07217	5.22886	4.67046
22		259	844	6101	52		158	945	217
22	30	181	922	301	52	30	099	3004	338
23		104	999	501	53		040	063	558
23	30	027	9076	701	53	30	6982	121	728
24		0950	153	900	54		923	180	897
24	30	0.10873	5.19230	4.57098	54	30	0.06865	5.23238	4.68066
25		797	306	296	55		808	295	235
25	30	721	382	494	55	30	751	352	473
26		646	457	690	56		693	410	571
26	30	570	533	886	56	30	637	466	738
27		495	608	8082	57		580	523	905
27	30	0.10421	5.19682	4.58277	57	30	0.06524	5.23579	4.69071
28		347	956	471	58		468	635	237
28	30	272	831	665	58	30	412	691	403
29		199	904	859	59		357	746	568
29	30	126	977	9052	59	30	302	801	733
30		053	20050	244	60		247	856	897

LOGARITHMIC SOLAR TABLES.

H. IV.

M	S.	H.E.T.	M. T.	R.	M.	S.	H.E.T.	M. T.	R.
0	30	0.06192	5.23911	4.70061	30	30	0.03399	5.26704	4.79192
1		138	965	224	31		360	743	334
1	30	084	4019	387	31	30	322	781	475
2		030	073	550	32		283	820	615
2	30	5997	126	712	32	30	245	858	756
3		924	179	874	33		207	896	896
3	30	0.05871	5.24232	4.71036	33	30	0.03170	5.26933	4.80035
4		818	285	197	34		132	971	175
4	30	766	337	357	34	30	095	7008	314
5		714	389	518	35		058	045	455
5	30	662	441	678	35	30	021	082	491
6		610	493	837	36		2985	118	729
6	30	0.05559	5.24544	4.71996	36	30	0.02949	5.27154	4.80866
7		508	595	2155	37		913	190	1004
7	30	457	646	313	37	30	877	226	141
8		406	697	471	38		841	262	277
8	30	356	747	628	38	30	806	297	414
9		306	797	785	39		771	332	550
9	30	0.05257	5.24846	4.72942	39	30	0.02736	5.27367	4.81686
10		207	896	3098	40		701	402	821
10	30	158	954	254	40	30	667	436	956
11		109	994	410	41		633	470	2091
11	30	060	5043	565	41	30	599	504	226
12		012	091	720	42		565	538	360
12	30	0.04964	5.25139	4.73874	42	30	0.02532	5.27571	4.82494
13		916	187	4028	43		499	604	628
13	30	868	235	182	43	30	466	637	761
14		821	282	335	44		433	670	894
14	30	774	329	488	44	30	400	703	3026
15		727	376	641	45		368	735	159
15	30	0.04680	5.25423	4.74793	45	30	0.02336	5.27767	4.83291
16		634	469	945	46		304	799	423
16	30	588	515	5096	46	30	273	830	554
17		542	561	247	47		241	862	685
17	30	496	607	398	47	30	210	893	816
18		451	652	549	48		179	924	947
18	30	0.04406	5.25697	4.75699	48	30	0.02149	5.27954	4.84077
19		361	742	848	49		118	985	207
19	30	317	786	997	49	30	088	8015	337
20		272	831	6146	50		058	045	466
20	30	228	875	295	50	30	028	075	595
21		185	918	443	51		1999	104	724
21	30	0.04141	5.25962	4.76591	51	30	0.01969	5.28134	4.84852
22		098	6005	738	52		940	163	981
22	30	055	048	885	52	30	912	191	5108
23		012	091	7032	53		883	220	236
23	30	3969	134	179	53	30	854	249	303
24		927	176	325	54		826	277	400
24	30	0.03885	5.26218	4.77470	54	30	0.01798	5.28305	4.85617
25		845	260	616	55		771	332	744
25	30	802	301	761	55	30	743	360	870
26		760	343	926	56		716	387	996
26	30	719	384	8050	56	30	687	414	6121
27		678	425	194	57		662	441	246
27	30	0.03638	5.26465	4.78338	57	30	0.01635	5.28468	4.86372
28		597	506	481	58		609	494	496
28	30	557	546	624	58	30	583	520	621
29		517	586	767	59		557	546	745
29	30	478	625	908	59	30	531	572	869
30		438	665	9051	60		506	597	992

LOGARITHMIC SOLAR TABLES.

H. V.

M	S.	H.E.T.	M. T.	R.	M.	S.	H.E.T.	M. T.	R.
0	30	0.01480	5.28623	4.87116	30	30	0.00361	5.29742	4.94034
1		455	648	232	31		349	754	141
1	30	430	673	369	31	30	337	766	249
2		406	697	484	32		325	778	356
2	30	381	722	606	32	30	313	790	463
3		357	746	728	33		302	801	570
3	30	0.01333	5.28770	4.87850	33	30	0.00291	5.29812	4.94676
4		310	793	971	34		280	823	782
4	30	286	817	8093	34	30	269	834	888
5		263	840	213	35		259	844	994
5	30	240	863	334	35	30	249	854	5100
6		217	886	454	36		239	864	295
6	30	0.01194	5.28909	4.88574	36	30	0.00229	5.29874	4.95310
7		172	931	694	37		219	884	415
7	30	150	953	814	37	30	210	893	520
8		128	975	933	38		200	903	624
8	30	106	997	9052	38	30	191	912	728
9		084	9010	171	39		183	920	832
9	30	0.01063	5.29040	4.89289	39	30	0.00174	5.29929	5.95936
10		042	061	407	40		166	937	6040
10	30	021	082	525	40	30	157	946	143
11		000	103	643	41		149	954	246
11	30	0980	123	760	41	30	142	961	349
12		960	143	877	42		134	969	451
12	30	0.00940	5.29163	4.89994	42	30	0.00127	5.29976	4.96554
13		920	183	90111	43		120	983	656
13	30	900	203	227	43	30	113	990	758
14		881	222	343	44		106	997	860
14	30	862	241	459	44	30	099	30004	961
15		843	260	575	45		093	010	7062
15	30	0.00824	5.29279	4.90690	45	30	0.00087	5.30016	4.97163
16		805	298	805	46		081	022	264
16	30	787	316	920	46	30	075	028	365
17		769	334	1034	47		070	033	465
17	30	751	352	149	47	30	065	038	565
18		733	370	263	48		060	043	665
18	30	0.00716	5.29387	4.91377	48	30	0.00055	5.30048	4.97915
19		699	404	490	49		050	053	865
19	30	682	421	603	49	30	046	058	964
20		665	428	716	50		041	062	8063
20	30	648	445	830	50	30	037	066	162
21		632	471	942	51		033	070	261
21	30	0.00616	5.29487	4.92054	51	30	0.00030	5.30073	4.98359
22		600	503	166	52		026	077	457
22	30	584	519	278	52	30	023	080	555
23		568	535	390	53		020	083	653
23	30	553	550	501	53	30	017	086	751
24		538	565	612	54		015	088	848
24	30	0.00523	5.29580	4.92723	54	30	0.00013	5.30090	4.98945
25		508	595	833	55		010	092	9042
25	30	494	609	944	55	30	008	094	139
26		480	623	3054	56		007	096	235
26	30	466	637	164	56	30	005	098	332
27		452	651	273	57		004	099	428
27	30	0.00438	5.29665	4.93383	57	30	0.00003	5.30100	4.99524
28		425	678	498	58		002	101	619
28	30	412	691	601	58	30	001	102	715
29		399	704	709	59		000	103	810
29	30	386	717	817	59	30	000	103	905
30		373	730	926	60		000	103	5.00000

Q

T A B L E

OF THE

EQUATION of TIME.

Days	Jan.		Feb.		March		April		May		June		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.	M.	S.
1	4	14	14	15	12	47	3	58	3	14	2	56	2	56	5	38	0	18	10	16	15	59	10	20
2	4	42	14	22	12	35	3	40	3	22	2	48	3	7	5	34	0	36	10	34	16	1	9	56
3	5	9	14	28	12	22	3	22	3	30	2	39	3	19	5	30	0	55	10	52	16	0	9	32
4	5	36	14	34	12	8	3	3	3	37	2	29	3	30	5	26	1	14	11	10	15	59	9	8
5	6	4	14	38	11	54	2	45	3	43	2	19	3	41	5	20	1	34	11	28	15	57	8	43
6	6	30	14	42	11	40	2	26	3	49	2	9	3	51	5	14	1	53	11	45	15	54	8	17
7	6	57	14	45	11	24	2	9	3	53	1	59	4	8	5	8	2	12	12	2	15	51	7	51
8	7	23	14	47	11	9	1	51	3	57	1	48	4	8	5	2	2	32	12	18	15	47	7	25
9	7	48	14	48	10	54	1	34	4	1	1	37	4	15	4	52	2	52	12	33	15	41	6	59
10	8	12	14	49	10	38	1	17	4	4	1	25	4	22	4	46	3	13	12	49	15	35	6	30
11	8	37	14	49	10	21	1	1	4	7	1	14	4	29	4	37	3	33	13	4	15	29	6	3
12	9	2	14	48	10	4	0	45	4	10	1	2	4	46	4	28	3	53	13	18	15	21	5	35
13	9	26	14	46	9	47	0	28	4	11	0	50	4	53	4	18	4	14	13	32	15	13	5	6
14	9	48	14	44	9	30	0	12	4	12	0	37	5	0	4	8	4	34	13	46	15	3	4	38
15	10	10	14	41	9	13	0	3	4	13	0	25	5	7	3	57	4	55	13	59	14	53	4	9
16	10	31	14	37	8	55	0	18	4	12	0	13	5	13	3	46	5	15	14	11	14	41	3	40
17	10	50	14	32	8	37	0	33	4	11	0	0	5	18	3	34	5	36	14	23	14	29	3	10
18	11	9	14	27	8	19	0	48	4	10	0	13	5	24	3	21	5	56	14	34	14	17	2	40
19	11	27	14	21	8	1	1	2	4	8	0	26	5	29	3	8	6	17	14	44	14	3	2	10
20	11	45	14	15	7	43	1	16	4	6	0	39	5	33	2	55	6	38	14	54	13	49	1	40
21	12	2	14	7	7	25	1	28	4	3	0	52	5	36	2	42	6	58	15	4	13	34	1	11
22	12	18	13	59	7	6	1	41	4	0	1	45	39	2	27	7	19	15	13	13	17	0	41	
23	12	30	13	50	6	47	1	54	3	56	1	17	5	42	2	13	7	39	15	21	13	0	0	11
24	12	47	13	41	6	28	2	6	3	51	1	30	5	42	1	58	7	59	15	28	12	43	0	19
25	13	2	13	31	6	10	2	16	3	46	1	43	5	45	1	42	8	19	15	34	12	24	0	49
26	13	16	13	21	5	51	2	27	3	40	1	56	5	46	1	26	8	39	15	40	12	5	1	19
27	13	28	13	10	5	32	2	38	3	34	2	8	5	46	1	9	8	58	15	45	11	45	1	49
28	13	38	12	59	5	14	2	48	3	28	2	20	5	45	0	52	9	18	15	50	11	25	2	18
29	13	48			4	55	2	57	3	21	2	32	5	44	0	35	9	37	15	53	11	4	2	47
30	13	58			4	30	3	6	3	13	2	44	5	42	0	17	9	57	15	56	10	42	3	16
31	14	7			4	17		3	5		5	40	0	1		15	58				1	3	45	

Watch too fast till the 14th day of April; from thence too slow till the 17th of June.

Watch too fast till the 31st of August; from thence too slow till the 23d of December.

This Equation of Time is caused by an inequality of the Sun's motion from East to West, according to the succession of sines; for the swifter the Sun is in his annual motion from West to East, the slower he must be in his diurnal motion from East to West.

A TABLE of SIRIUS,

The GREAT DOG STAR,

PASSING THE

MERIDIAN of GREENWICH.

Days	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.
	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.	H. M.
1	10A.11	8A.7	6A.23	4A.30	2A.34	0A.26	10M.23	8M.24	6M.33	4M.42	2M.38	0M.27
2	10 6	8 3	6 20	4 26	2 30	0 22	10 19	8 20	6 30	4 39	2 34	0 22
3	10 2	8 0	6 16	4 22	2 26	0 18	10 15	8 17	6 26	4 35	2 30	0 18
4	9 56	7 56	6 12	4 18	2 22	0 18	10 11	8 13	6 22	4 31	2 26	0 13
5	9 52	7 52	6 9	4 15	2 18	0 10	10 7	8 10	6 19	4 27	2 22	0 9
6	9 49	7 48	6 5	4 11	2 14	0 6	10 3	8 6	6 15	4 24	2 18	0 4
7	9 45	7 44	6 2	4 7	2 10	0 1	10 0	8 2	6 12	4 20	2 13	0A 0
8	9 41	7 40	5 58	4 3	2 6	11M.56	9 56	7 59	6 8	4 16	2 8	11 56
9	9 37	7 37	5 54	4 0	2 1	11 53	9 52	7 56	6 4	4 11	2 3	11 51
10	9 33	7 33	5 50	3 56	1 57	11 49	9 48	7 52	6 0	4 7	1 59	11 47
11	9 28	7 30	5 46	3 52	1 53	11 44	9 44	7 48	5 75	4 3	1 55	11 42
12	9 24	7 26	5 43	3 48	1 49	11 40	9 40	7 44	5 53	3 59	1 50	11 38
13	9 20	7 22	5 39	3 44	1 45	11 36	9 36	7 41	5 50	3 55	1 46	11 34
14	9 16	7 18	5 35	3 40	1 40	11 32	9 32	7 37	5 46	3 51	1 42	11 29
15	9 12	7 14	5 31	3 36	1 36	11 28	9 28	7 33	5 42	3 48	1 37	11 25
16	9 8	7 10	5 28	3 32	1 32	11 24	9 25	7 30	5 38	3 43	1 33	11 21
17	9 4	7 7	5 24	3 28	1 28	11 20	9 21	7 26	5 34	3 39	1 29	11 16
18	9 0	7 3	5 21	3 24	1 24	11 16	9 17	7 23	5 30	3 34	1 25	11 12
19	8 56	7 0	5 18	3 20	1 20	11 12	9 13	7 20	5 26	3 30	1 2	11 8
20	8 53	6 56	5 14	3 17	1 16	11 8	9 9	7 16	5 23	3 26	1 15	11 3
21	8 50	6 52	5 11	3 13	1 12	11 4	9 6	7 12	5 19	3 23	1 11	10 57
22	8 46	6 48	5 7	3 9	1 8	11 0	9 2	7 8	5 15	3 18	1 7	10 53
23	8 42	6 45	5 4	3 5	1 4	10 56	8 58	7 4	5 12	3 14	1 2	10 47
24	8 38	6 41	5 0	3 2	1 0	10 52	8 54	7 0	5 8	3 10	0 58	10 44
25	8 34	6 37	4 56	2 58	0 56	10 48	8 50	6 57	5 4	3 6	0 54	10 40
26	8 30	6 34	4 52	2 54	0 51	10 44	8 46	6 53	5 0	3 2	0 50	10 36
27	8 26	6 31	4 48	2 50	0 47	10 40	8 43	6 50	4 57	2 58	0 45	10 31
28	8 22	6 27	4 44	2 46	0 43	10 36	8 39	6 46	4 53	2 54	0 40	10 27
29	8 18		4 40	2 42	0 38	10 31	8 35	6 43	4 5	2 50	0 35	10 23
30	8 15		4 37	2 38	0 34	10 27	8 32	6 40	4 46	2 46	0 31	10 19
31	8 11		4 33		0 30		8 28	6 36		2 42		10 15

A

T A B L E

S H E W I N G

How many MILES is a DEGREE

In all LATITUDES.

DL	M. tenths		DL	M. tenths		DL	M. tenths		DL	M. tenths		DL	M. tenths		DL	M. tenths	
1	59	99	19	56	73	37	47	92	55	34	41	73	17	54			
2	59	96	20	56	38	38	47	38	56	33	53	74	16	53			
3	59	92	21	56	01	39	46	62	57	32	68	75	15	52			
4	59	98	22	55	63	40	45	95	58	31	79	76	14	51			
5	59	77	23	55	23	41	45	28	59	30	90	77	13	50			
6	59	67	24	54	81	42	44	59	60	30	00	78	12	48			
7	59	56	25	54	38	43	43	88	61	29	19	79	11	45			
8	59	42	26	53	93	44	43	16	62	28	17	80	10	42			
9	59	26	27	53	56	45	42	43	63	27	24	81	9	38			
10	59	08	28	52	97	46	41	68	64	26	30	82	8	35			
11	58	89	29	52	47	47	40	92	65	25	36	83	7	32			
12	58	68	30	51	96	48	40	15	66	24	41	84	6	28			
13	58	46	31	51	43	49	39	36	67	23	45	85	5	23			
14	58	22	32	50	88	50	38	57	68	22	48	86	4	18			
15	57	95	33	50	32	51	37	76	69	21	50	87	3	14			
16	57	67	34	49	74	52	36	94	70	20	52	88	2	09			
17	57	37	35	49	15	53	36	11	71	19	54	89	1	05			
18	57	06	36	48	54	54	35	26	72	18	55						

[This BOOK is ENTERED at STATIONERS-HALL.]

2 MA 67

